INSTRUCTION
MANUAL

2901

TIME-MARK GENERATOR

TEKTRONIX MANUFACTURERS OF CATHODE-RAY OSCILLOSCOPES

INSTRUCTION MANUAL

Serial Number B010134

2901 TIME-MARK GENERATOR

Tektronix, Inc.
S.W. Millikan Way ● P. O. Box 500 ● Beaverton, Oregon 97005 ● Phone 644-0161 ● Cables: Tektronix

070-0995-00

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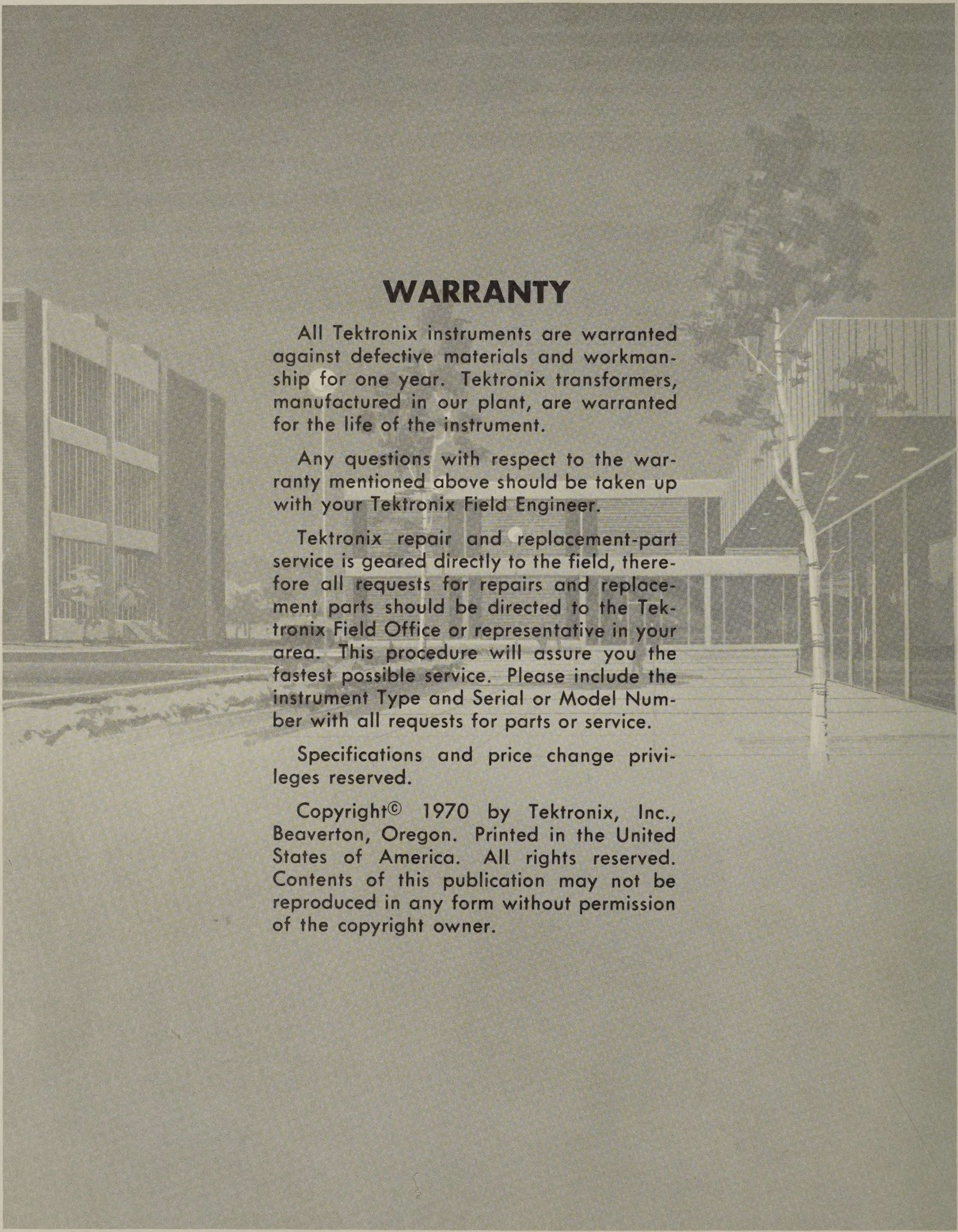

WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial or Model Number with all requests for parts or service.

Specifications and price change privileges reserved.

TABLE OF CONTENTS

Abbreviations and symbols used in this manual are based on or taken directly from IEEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.

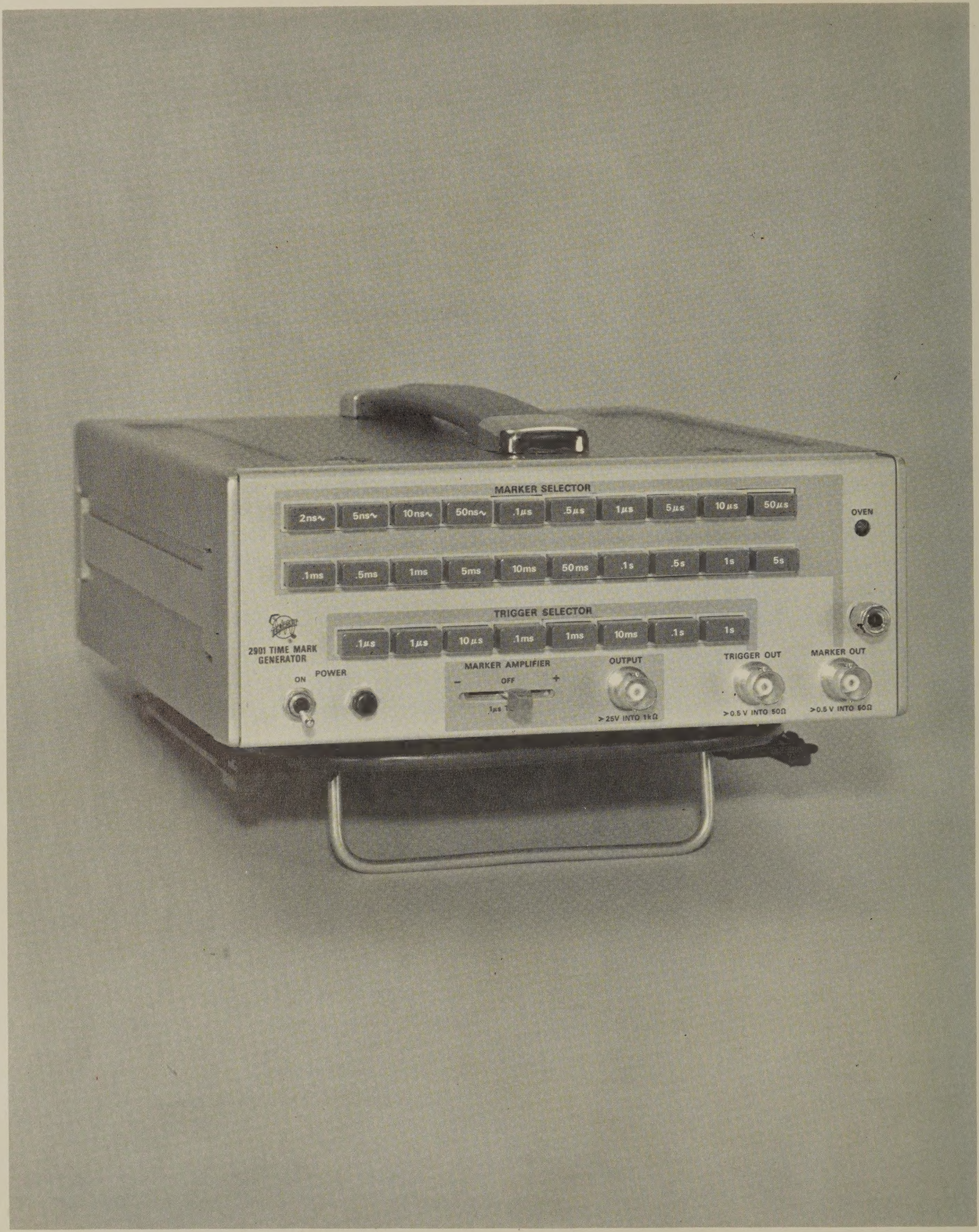

Fig. 1-1. 2901 Time-Mark Generator.

SECTION 1
SPECIFICATIONS

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

The 2901 Time-Mark Generator is a compact, wide range, solid state instrument that provides accurate time and frequency markers for calibrating and verifying both the sweep time accuracy of oscilloscopes and the frequency dispersion of spectrum analyzers. Marker frequencies are controlled by a temperature-stabilized 10 MHz crystal oscillator. Marker output selections include four sine-wave frequencies (20 MHz, 100 MHz, 200 MHz, 500 MHz) and sixteen marker intervals (.1 μs to 5 s) in 1-5-10 sequence. A marker amplifier output provides either positive or negative-going high level markers (1 μs to 5 s) with minimum amplitude of 25 V into 1 kΩ. Eight trigger intervals (.1 μs to 1 s) are also provided in 1-10 sequence time coincident with the markers.

The instrument is provided with an attached three-wire power cord with a three-terminal polarized plug to connect to the power source. The third wire, directly connected to the instrument frame, is intended to ground the instrument to protect operating personnel, as recommended by national and international safety codes.

The instrument should be operated from a power source with its neutral at or near ground (earth) potential. It is not intended for operation from two phases of a multiphase system, or across the legs of a single-phase three wire system.

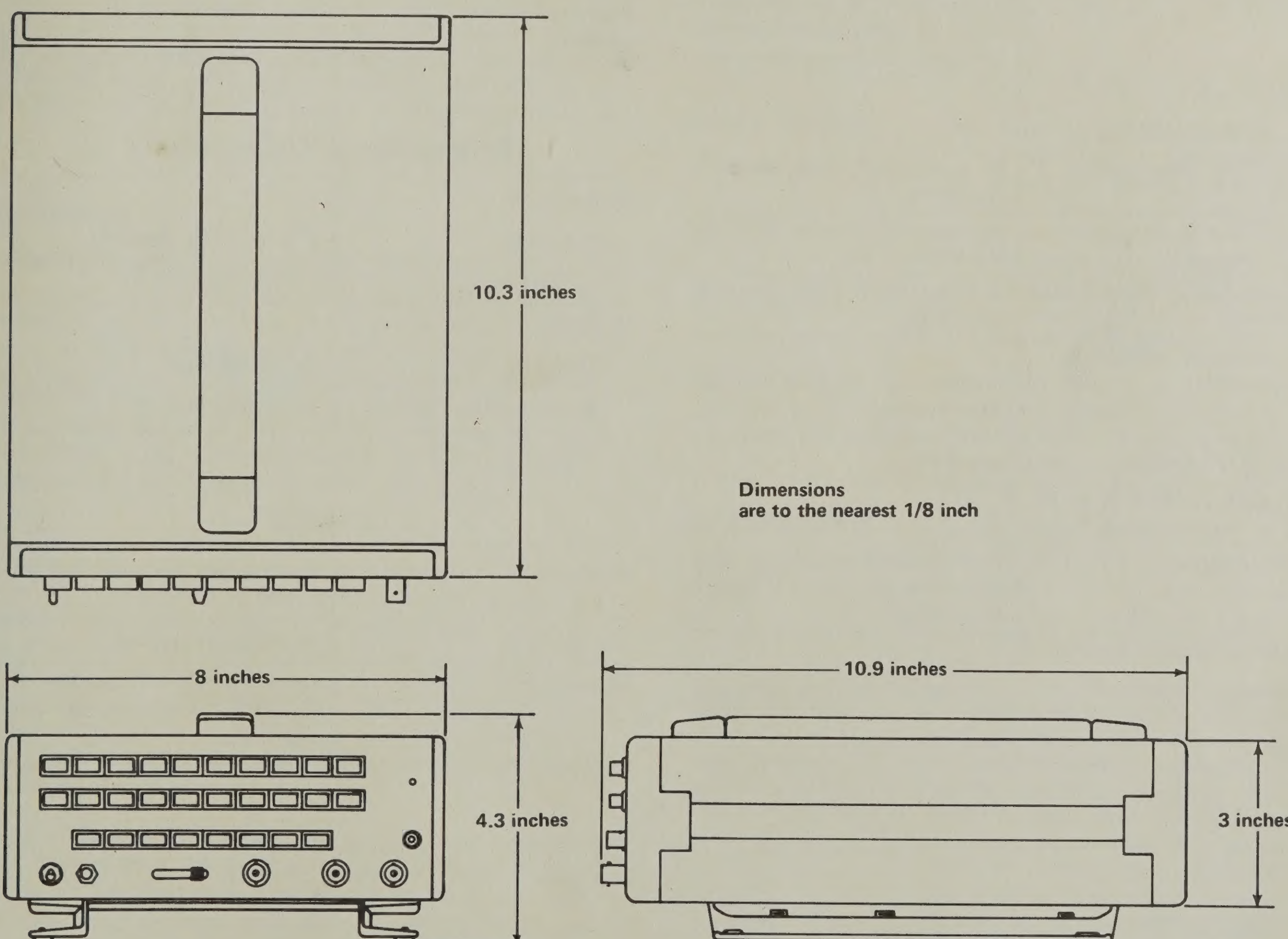

Fig. 1-2. 2901 dimensions.

Performance Conditions

Characteristics described in this section are valid over the stated environmental range, for instruments calibrated at an ambient temperature between +20°C and +30°C. The crystal oven indicator on the instrument must show that normal operating temperature has been attained (power applied for 2 hours or more). The instrument also requires at least a 5 minute warmup period after the POWER switch is switched on.

ELECTRICAL CHARACTERISTICS

Characteristic	Performance Limits
Time-Markers	
Periods	Sinusoidal—2 ns, 5 ns, 10 ns, 50 ns. Periodic Pulses— .1 µs to 5 s in 1-5-10 sequence.
Accuracy	Period within 0.001% (10 P/M[1], 20° C to 30° C). Period within 0.002% (20 P/M[1], 0° C to 50° C).
Stability	Within 3 P/M in 24 hours (20°C to 30°C) at .1 µs (10 MHz) after 2 hours operation.
Amplitude	
MARKER OUTput	
2 ns (sine wave)	At least 0.3 V peak to peak into 50 Ω.
5 ns to 50 ns (sine wave)	At least 0.5 V peak to peak into 50 Ω.
.1 µs to 5 s (markers)	At least 0.5 V peak to peak into 50 Ω.
MARKER AMPLIFIER OUTPUT	Positive or negative-going time-markers (.1 µs to 5 s). Peak amplitude 25 V minimum into 1 kΩ.
TRIGGER OUTput (.1 µs to 1 s in decade steps).	
Amplitude	Positive-going triggers at least 0.5 V into 50 Ω or 1 V into 1 MΩ, 150 pF.
EXTernal CLOCK INPUT	
Required Amplitude	At least 2 V peak to peak sine wave or at least 2 V peak pulse amplitude.
Maximum Safe Input Amplitude	5 V (DC + peak AC)
Frequency Range	50 kHz or less to 10 MHz. Lower frequencies may be used if the pulse rate of rise is equal to or faster than 1 V/µs.
Input Impedance	50 Ω within 20%.

Input Power Requirements

Line Voltage	
115 V Range	90 V or less to at least 136 V.
230 V Range	180 V or less to at least 272 V.
Crest Factor (Ratio: Peak/RMS)	At least 1.3
Line Current	240 mA maximum
Power	30 watts maximum, at 115 V, 60 Hz.
Line Frequency Range	48 Hz to 440 Hz
Fuse (115 V and 230 V Ranges)	0.3 A Fast-blow type.

Environmental Characteristics

Temperature	
Operating	0°C to 50°C Ambient
Non-operating	—40°C to 65°C
Altitude	
Operating	To 15,000 feet
Non-operating	To 50,000 feet

Physical

Finish	Front panel is anodized aluminum
Weight (net)	Approximately 8 lbs.
Dimensions	Approximately 11 inches × 8 inches × 4⅓ inches. See Fig. 1-2

[1]Parts per million.

SECTION 2
OPERATING INSTRUCTIONS

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

The 2901 Time-Mark Generator provides accurate time-markers from 5 s to .1 μs intervals and sine wave frequencies from 50 ns (20 MHz) to 2 ns (500 MHz). Marker intervals or frequencies may be selected by depressing a series of self canceling pushbuttons. Time-markers may be stacked (not useful for sine-waves) by pushing the desired marker buttons simultaneously.

Trigger pulses, from .1 μs to 1 s, coincident with the corresponding time-markers, are available at the TRIGGER OUTput connector when any of the eight TRIGGER SELECTOR pushbuttons are depressed.

High amplitude (25 V peak to peak, or greater, into 1 kΩ) markers, positive-going or negative-going polarity, from 1 μs to 5 s are available at the MARKER AMPLIFIER OUTPUT connector when the MARKER AMPLIFIER switch is in either the + or — positions. MARKER AMPLIFIER switch should be in the OFF position when the amplifier is not used.

Installation

The 2901 instrument is provided with an attached three-wire power cord with a three-terminal polarized plug for connection to the power source. The third wire is directly connected to the instrument frame and is intended to ground the instrument to protect operating personnel, as recommended by the national and international safety codes. Color coding of cord conductors follows the National Electrical Code: Line conductor—black, neutral conductor—white, safety earth (grounding) conductor—green.

Operate the 2901 from a power source with its neutral at or near ground (earth) potential. It is not intended for operation from two phases of a multi-phase system, or across the legs of a single phase, three-wire system. Line voltage range, for the 115 V selector position, is 90 V to 136 V (not to exceed 177 V); and 180 V to 272 V (not to exceed 352 V) for the 230 V range of the line voltage selector positions. Line frequency range is 48 Hz to 440 Hz.

Select the appropriate line voltage range for your situation by switching the screwdriver operated Line Voltage selector on the back panel (see Fig. 2-1) to the correct position, and plug the power cord into a suitable power source. Allow two hours for the crystal oven temperature to stabilize (to minimum drift), then turn the POWER switch to ON and allow 5 minutes for the instrument to warm up.

NOTE

The crystal oven indicator light is across the heater winding for the crystal oven. It monitors the operation of the thermostat, and indicates when the heater is on. The crystal oven power is independent of the POWER switch.

FUNCTION OF CONTROLS AND CONNECTORS

All selectors and connectors required for normal operation of the 2901 are located on the front and rear panels of the instrument (Fig. 2-1). Their functions are described in the following table.

MARKER SELECTOR	Self-canceling pushbuttons, that select individual or combinations of time-marker intervals and frequencies, for the MARKER OUTput connector. Markers up to two decades apart may be stacked by depressing the desired pushbuttons simultaneously (not applicable for the sine-wave frequencies).
MARKER OUTput	Output for sine wave or marker periods are selected by the MARKER SELECTORS. Output amplitude of the markers, at least 0.5 V peak to peak into 50 Ω load.
TRIGGER SELECTOR	Series of eight self-canceling pushbuttons that select output trigger pulses from .1 μs to 1 s in decade steps. Trigger pulses are coincident with the corresponding time-markers.
MARKER AMPLIFIER	Three position switch (+ OFF —) that provides amplified positive or negative-going time-markers at the OUTPUT connector. Selected markers from 1 μs to 5 s are amplified to at least 25 V peak into 1 kΩ. Does not operate over the 2 ns to .5 μs range. Switch should be in the OFF position when the amplifier is not used.
OUTPUT	Output connector for the amplified time-markers. Output amplitude

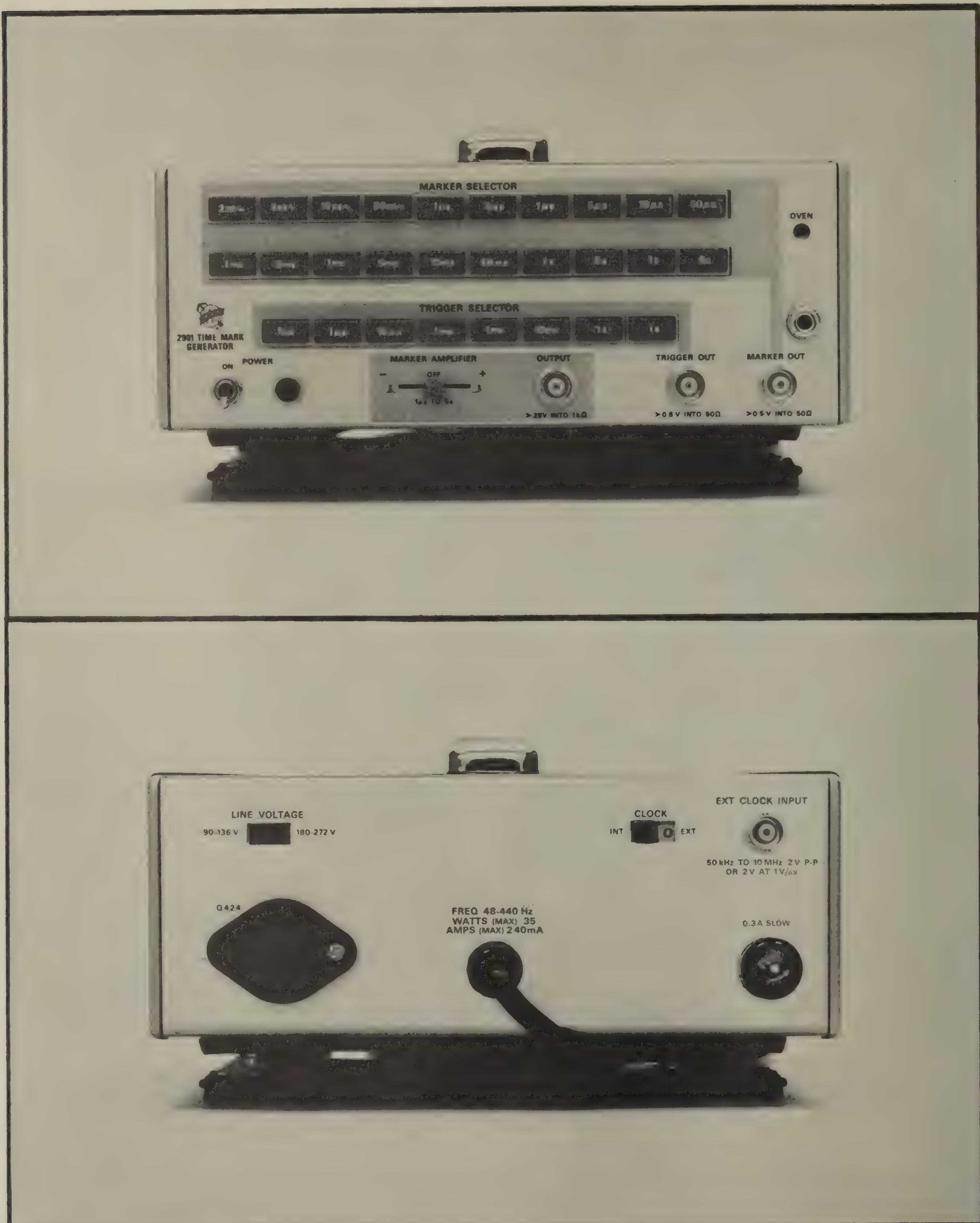

Fig. 2-1. Front and rear-panel selectors and connectors.

	of the markers is at least 25 V peak, into a 1 kΩ load.
OVEN Indicator	Indicates crystal oven heating. Crystal oven and indicator power are independent of the POWER switch. Allow approximately 2 hours, after the power cord has been connected to a power source, for the crystal temperature to stabilize. The instrument can be used within 5 minutes after the POWER switch has been turned on; however, frequency stability will be reduced.
CLOCK (INT-EXT) Switch (Rear Panel)	Selects either the internal oscillator or an external signal as the frequency source for the countdown circuits.
EXT CLOCK INPUT Connector	Used for external oscillator signal. Input impedance approximately 50 Ω. External clock frequency is counted down in a 1-5-10 sequence, to 50 x 10^6 times the input period. Frequency range 50 kHz or less to at least 10 MHz. Required signal input amplitude is 1 volt minimum peak to peak sine wave to 5 V (peak AC + DC) maximum. Reset level +50 mV or less. Frequencies below 50 kHz may be used if the rate of rise is 1 V/μs. The 0.1 μs MARKER SELECTOR pushbutton is the ×1 input signal period, with the lower order selector buttons counting the input period down in 1-5-10 sequence to the longest (5 s pushbutton) period. 2 ns to 50 ns sinewave marker selections are inoperative with an external signal, unless the input frequency is 10 MHz.
LINE VOLTAGE Selector	Screwdriver operated switch that selects transformer primary windings for either 90 V-136 V or 180 V-272 V nominal line voltage operation.

General Operating Information

The crystal oven temperature has stabilized when the OVEN indicator cycles on and off at regular intervals. Period of the cycle is about 30 seconds, depending on the ambient temperature.

Terminate the output into 50 Ω for optimum marker definition and consistent marker amplitude.

NOTES

SECTION 3
CIRCUIT DESCRIPTION

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

This section describes the circuitry used in the 2901 Time-Mark Generator. A block diagram analysis is first presented to describe the relationship of each major circuit to the overall operation of the instrument. Each major circuit is then described in detail. The objective of this description is to familiarize the reader sufficiently with the instrument circuit theory to enable the technician to troubleshoot, calibrate, and operate the instrument.

Functional block diagrams and simplified schematics are included in this section to help illustrate circuit operation. Detailed circuit diagrams are provided in the Diagrams section.

Block Diagrams

The 2901 Time-Mark Generator consists of a series of counter circuits and frequency multipliers. The counter circuits are clocked by an external signal source or the internal 10 MHz crystal controlled oscillator. A block diagram (Fig. 3-1) illustrates the operational sequence of the major circuits in the 2901.

When the CLOCK selector is in the INT position, the crystal oscillator frequency of 10 MHz is applied through independent switches to four multipliers; for the 50 ns, 10 ns, 5 ns, and 2 ns marker intervals. The oscillator or clock frequency is also applied to countdown circuits for the time-marker periods .1 μs to 5 s. Intergrated flip-flop circuits count the basic .1 μs (10 MHz) clock period down by 5, then by 2, to the longest (5 s) marker interval. Pushbutton (MARKER SELECTOR) switches apply the output from the counters to the OUTput connector, through an output amplifier. Time-markers 1 μs and below are amplified to an amplitude of at least 25 V peak by the marker amplifier when the MARKER AMPLIFIER selector is switched to either the + or — position. These high level markers, of either + or — polarity are delivered to the OUTput connector.

Time-mark intervals, in decade steps, from 1 s to .1 μs are also applied through TRIGGER SELECTOR pushbutton switches and a buffer amplifier stage to the TRIGGER OUTput connector. This provides trigger pulses that are coincident with the selected time-markers.

DETAILED CIRCUIT DESCRIPTION

Oscillator and Multipliers (Refer to Diagram ⟨1⟩)

The clock (base) frequency for the freqency multipliers must be the internal crystal controlled 10 MHz oscillator or on external 10 MHz frequency source. The clock frequency is applied to a frequency doubler containing Q25 and Q27 for the first multiplication. Output from the first multiplier is then applied through the 50 ns MARKER SELECTOR switch to a frequency quintupler, containing Q35 and Q37. The resultant 100 MHz signal is amplified by Q50 and then applied through either the 5 ns or 2 ns MARKER SELECTOR switches to a frequency doubler (containing Q57 and Q59) for 5 ns sine-wave period or to a frequency quintupler (containing Q75 and CR71) for 2 ns sine-wave period. Intermodulation distortion is minimized by the switch arrangement so that only the minimum number of multipliers are operating at one time.

Oscillator

The oscillator derives its stability and accuracy from a temperature stabilized 10 MHz crystal, connected between the collector and emitter of Q5. The series mode of the crystal is used to provide the positive feedback for oscillation. C8, in series with the crystal, provides a small frequency correction adjustment to pull the series resonant frequency of the crystal to an exact 10 MHz. L5 plus the series capacitance of C6 and C10 tunes the collector of Q5 for stable oscillator operation. Temperature compensation for Q5 is provided by feedback resistor R3 and diode CR1 in series with R1, from the base of Q5 to ground.

The output signal from the oscillator is amplified by Q13. L13 (in the collector load circuit of Q13) is adjusted to tune the output circuit of the amplifier to 10 MHz.

Multipliers

The first multiplier is a push-push amplifier designed to double the input freqency. Transformer T22 couples the signal, in phase opposition, to the bases of Q25 and Q27. The collectors are connected in parallel to a tuned output circuit consisting of L28 and C29 in series with C30. L28 tunes the collector circuit to 20 MHz. R25 adjusts the dynamic balance of the amplifier and reduces the intermodulation distortion from the 10 MHz fundamental. Bias voltage is applied to the amplifier input from the MARKER SELECTOR switching circuit (see description of Marker Amplifier and Selector Switching circuit) so that the doubler is disabled when any selection .1 μs and below is made.

The second multiplier for the 2901 quintuples the 20 MHz input frequency to generate 10 ns sine-wave periods. Q35 and Q37 are connected as active components for a push-pull amplifier with their collector loads tuned, by C39 and C43, to the fifth harmonic of the 20 MHz input. The input and output circuits for amplifier Q50 are tuned to 100 MHz by C47 and L50. The series resonant filter circuit C47 and L47 are

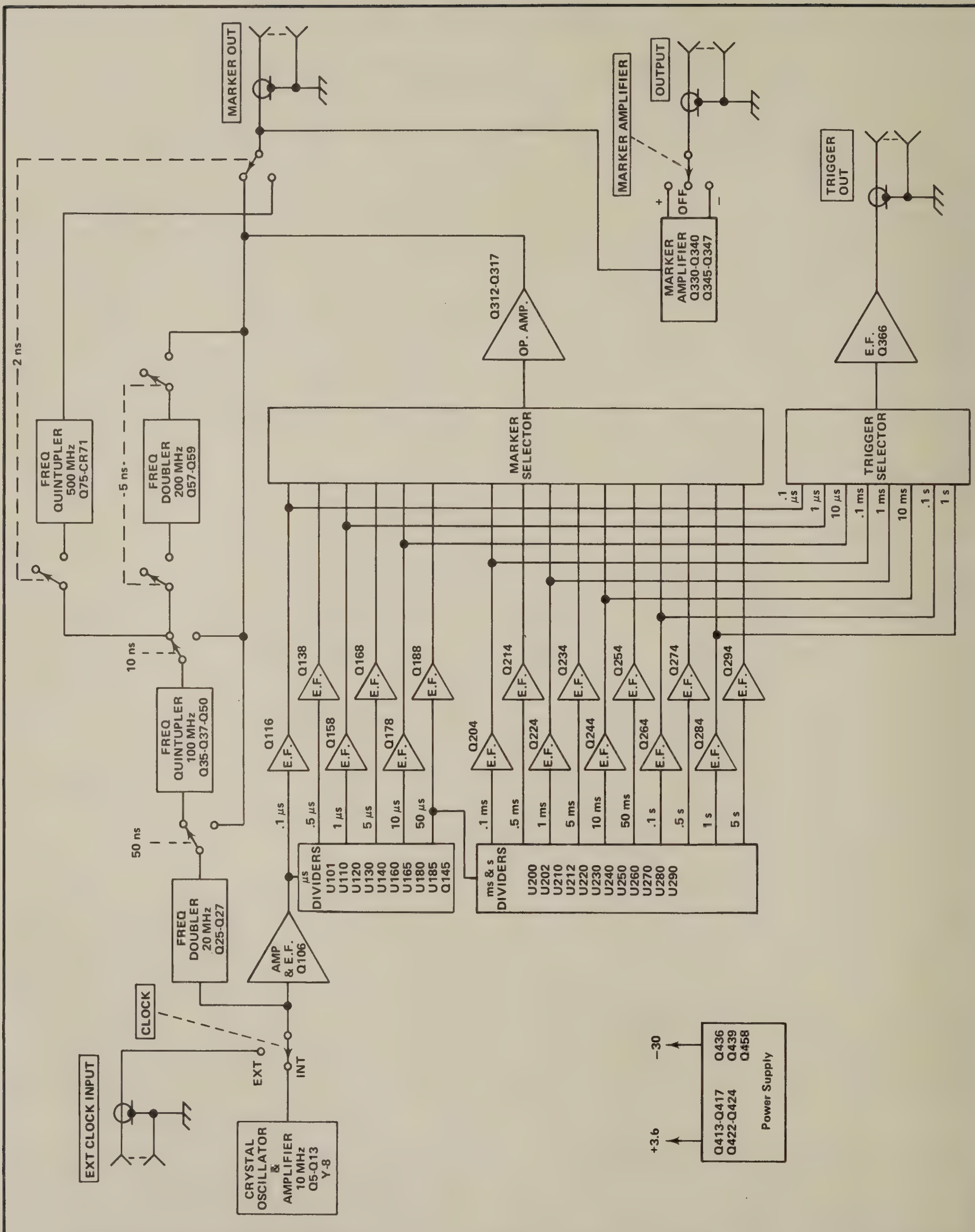

Fig 3-1. Functional block diagram.

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tuned to 100 MHz and provide a low impedance path for 100 MHz to the base of amplifier Q50 and helps suppress sub and multiple harmonics of 100 MHz. The collector load for Q50 consist of the parallel resonant circuit, L50 and C51 inseries with C52, tuned to 100 MHz.

The 5 ns marker generator consists of Q57 and Q59 connected as the active components of a push-push amplifier or frequency doubler. The collector load for this doubler is T62 in parallel with the series combination of C60 and C61. The output circuit is tuned to 200 MHz by C60.

The 2 ns generator quintuples the input 100 MHz (10 ns) frequency to generate the 500 MHz (2 ns) marker frequency. The input to this multiplier is a series tuned circuit, L66 and C66, tuned to 100 MHz. This filter circuit couples 100 MHz to the harmonic generator CR71 and isolates the harmonic generator from the output circuit for the 10 ns multiplier. CR71, a capacitance diode, generates high order harmonics of the 100 MHz input signal. Undesirable second and third order harmonics of this 100 MHz are filtered through two series tuned circuits consisting of L67-C67 (300 MHz) and L69-C69 (200 MHz). The fifth harmonic, or 5000 MHz is then filtered through series circuit L72 and C72, to the base of output amplifier Q75. The output load for the amplifier is tuned to 500 MHz by strip line filter C79 and L79. Capacitors C75 and C73 are adjusted to minimize intermodulation distortion in the output 500 MHz marker frequency.

Divider or Countdown Circuits

The divider circuits countdown the internal 10 MHz (.1 μs) crystal oscillator frequency, or an external clock frequency, in steps of 5 and 2. The countdown circuits are separated into two diagrams; the μs Dividers, and the ms and s Dividers

Definition of Terms and Logic Symbols Used in this Description

Intergrated circuits (IC's) are used in the countdown or divider circuits for the 2901 Time-Mark Generator. The following is a definition of the terms and logic symbols used in the description of the logic diagrams for the countdown circuits.

AND—A logic function which requires all inputs to be TRUE for the output to be TRUE.

Clock—A signal source which establishes the time intervals at which logic functions occur.

False—The non-activated state of logic circuit, input or output.

Flip-Flop—A bistable device (capable of assuming one of two stable states), which may assume a given state depending on the history of one or more inputs. The device will have one or more outputs which are described by the following truth table.

J_n	K_n	Q_{n+1}
0	0	Q_n
1	0	1
0	1	0
1	1	$\overline{Q}_n$

The JK flipflop may be clocked or unclocked. In the clocked mode, the flipflop switches (according to the input settings) when a clock pulse is applied. When the flipflop is used without clock pulses, the outputs respond to any change at the inputs.

Low—A voltage level, usually designated as the less positive of two logic levels.

NAND—A logic function which is an AND function with an inverted output.

One (1)—A symbol for the TRUE (activated) state. Another title for the Q output terminal of a flipflop. This output represents the TRUE state when the flipflop is set.

Positive Logic—A system of logic level identification where the more positive level is identified as a logical ONE (1), and the less positive level as a logical ZERO (0).

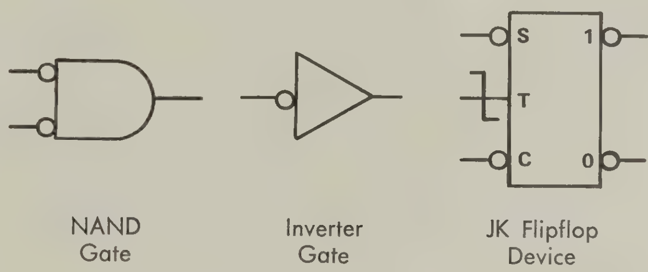
Set—To place a storage device in a prescribed state. To place a flipflop in the ONE state.

Toggle—To cause a flipflop to complement its output state.

True—The activated state of a logic circuit input or output.

Zero (0)—A symbol for the FALSE (non-activated) state. Another title for the Q output terminal of a flipflop. This output presents a FALSE state when the flipflop is set.

Logic symbols (Positive logic)



Microsecond Dividers (.1 μs to 50 μs)

Intergrated circuits are used extensively in the countdown or divider circuits for the 2901 Time-Mark Generator. The μs dividers contain JK flipflops, inverters and NAND gates.

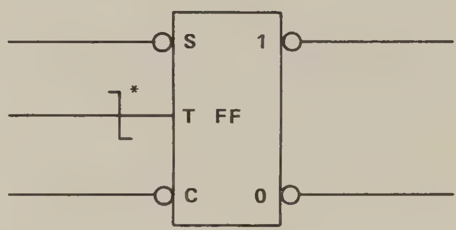
NOTE

Logic data on the IC's used in this circuit are provided in the Maintenance section.

The IC's for the .1 μs to 10 μs dividers are connected as semi-synchronous decade counters. The 10 μs to 50 ps counter is connected for a countdown of five. Logic and waveform diagrams plus truths tables for these devices are shown in Figs. 3-2 through 3-5. Synchronous counters are used for the high frequency counters to minimize propagation delay between the input clock and the output countdown pulses. The inverters U101, U110 and U130 are used as pulse shapers, inverter gates and time delay circuits for high frequency time-markers. The short period (.1 μs to 1 μs) time-markers are delayed so they coincide with the lower frequency markers.

Input and Output Circuit for .1 μs to 10 μs Counters

Input clock pulses from the 10 MHz oscillator (or external signal source) are shaped into square-wave pulses by the two



T_n		T_{n+1}	
S	C	1	0
H	H	Q_n	$\overline{Q}_n$
H	L	H	L
L	H	L	H
L	L	$\overline{Q}_n$	Q_n

* symbol indicates the device is sensitive to the negative transition of the input pulse.

Q_n is the true state of 1 output, in the time period t_n when the FF is set.

$\overline{Q}_n$ is the complementary or false state of the output during the time period t_n.

Fig. 3-2. Truth table for Type MC 890P and MC 891P dual JK flip flop IC's. Device toggles during negative transistion of the clock pulse when both S(set) and C(clear) inputs are low.

input inverter gates, U101D and U101E. The pulses are then applied, through emitter follower Q106, to the input of the first countdown circuit and the delay inverters (through U10A and U10B) to the .1 μs output circuit. The output, .1 μs pulses from inverter U10B, is coupled through a differentiating circuit (C111, R113 and R114) to the base of emitter follower Q116. The time constant of this differentiating circuit is short, so a sharp, narrow marker signal is applied to the output ampilfier Q116.

All of the output emitter followers for the time markers are biased at the threshold of conduction. Therefore, only the positive portion of the differentiated signal is coupled through the emitter followers to the MARKER SELECTOR switch and the TRIGGER SELECTOR switch.

.5 μs to 10 μs Dividers

A truth table for one half of the dual JK flipflop used in these countdown circuits is shown in Fig. 3-2. The JK flipflop will toggle (change state), during the negative transition of the input clock pulse, when both the S (set) and C (clear) terminals are low. The truth table also shows that the state of the outputs does not change when the S and C terminals are high.

Logic and waveform ladder diagrams for the first two decade counters (.1 μs to 10 μs) are shown in Fig. 3-3.

The .1 μs clock pulse is applied simultaneously to the T (toggle) input of each JK flipflop (U120A, U120B, U140A and U140B). For operation analysis, assume at t_o all the 1 outputs are high as illustrated on the ladder diagram.

At t_n the first negative transition of the input clock pulse produces the following events.

1. U120A toggles because both inputs S (pin 1) and C (pin 3) are low. The 1 (pin 14) output steps low.

2. U120B holds its high output state because its S and C inputs are high.

3. With both inputs to NAND gate U125A high, the output of the NAND gate is low. This output is inverted by U125B to produce a high at the S input of U140A.

4. The 1 output (pin 14) of U140A stays high and U140B holds its low state at the 0 (pin 8) output.

At t_{n+1}, the next clock pulse produces the following changes:

1. U120A again toggles and its 1 output steps high.

2. U120B toggles because its S and C inputs are now both low. The 1 output (pin 9) of U120B goes low. We now have a high and low input to the NAND gate U125A.

3. U140A and U140B outputs remain in the same state as existed at t_n.

At t_{n+2} the next negative transition of the clock pulse produces the following changes:

1. U120A toggles and its 1 output steps low.

2. U120B holds, because its S and C inputs are held high by the previous output state of U120A.

3. Both inputs to the NAND gate are now low. So the S input U140A is low.

4. U140A holds its state because its S input was high when the clock pulse occurred. The state of U140B remains unchanged.

At t_{n+3} the following events occur:

1. U120A toggles.

2. U120B toggles because inputs S and C are now both low.

3. U140A now toggles and its 1 output (pin 14) flops low. The 0 output (pin 13) steps high.

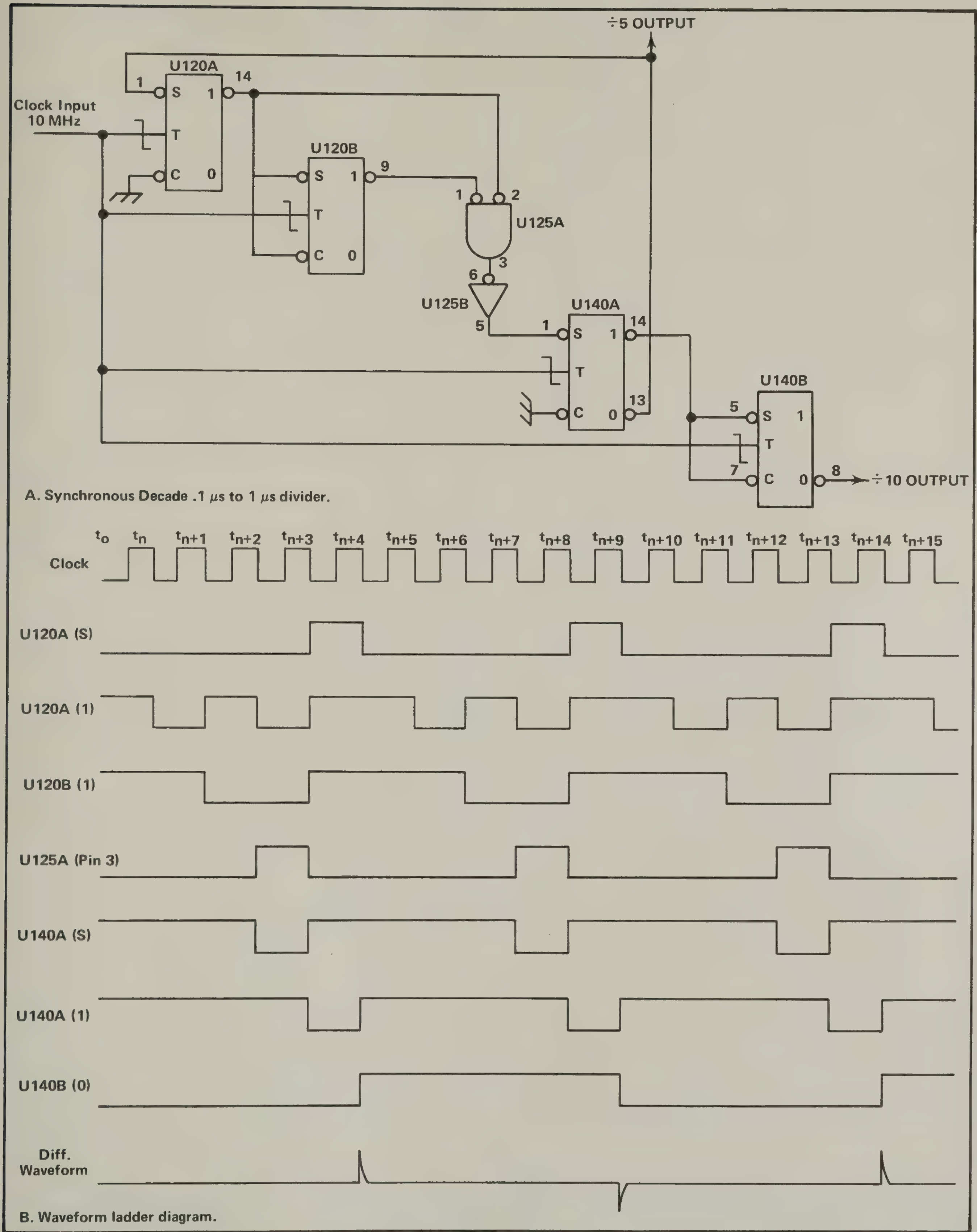
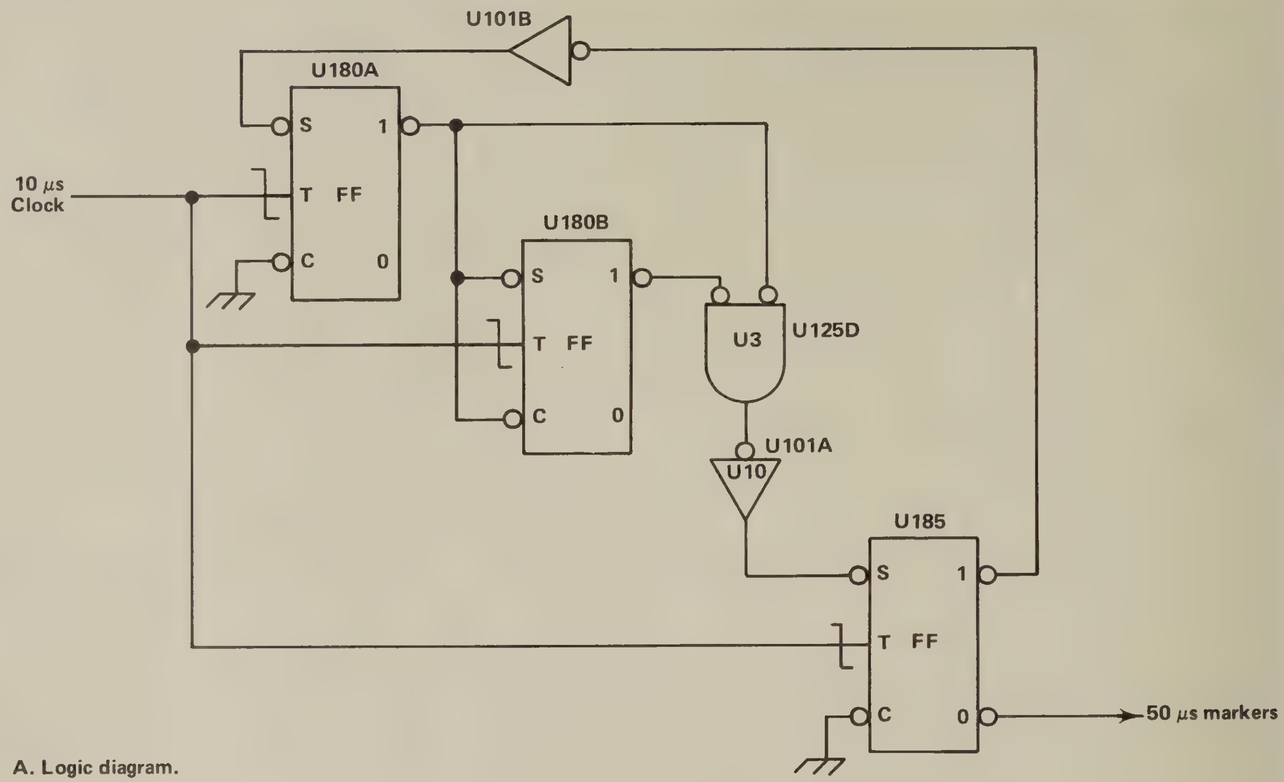
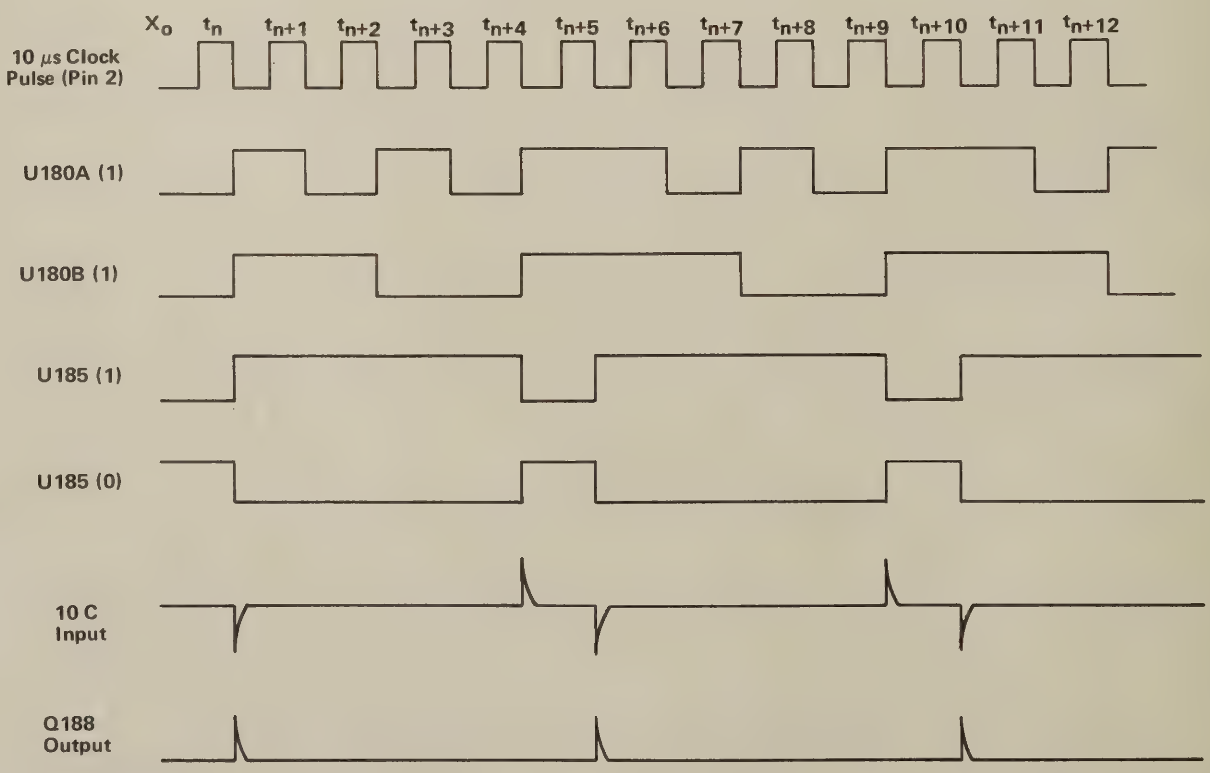


Fig. 3-3. Logic and waveform ladder diagram for the .1 μs to .5 μs and 1 μs to 5 μs dividers.

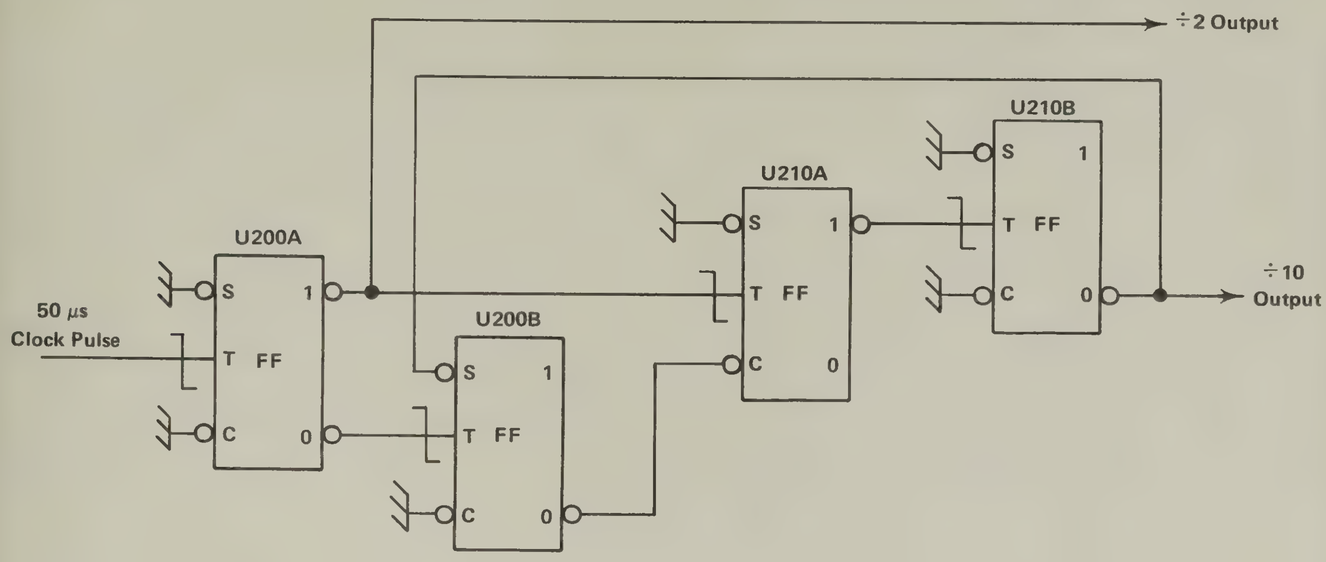


A. Logic diagram.

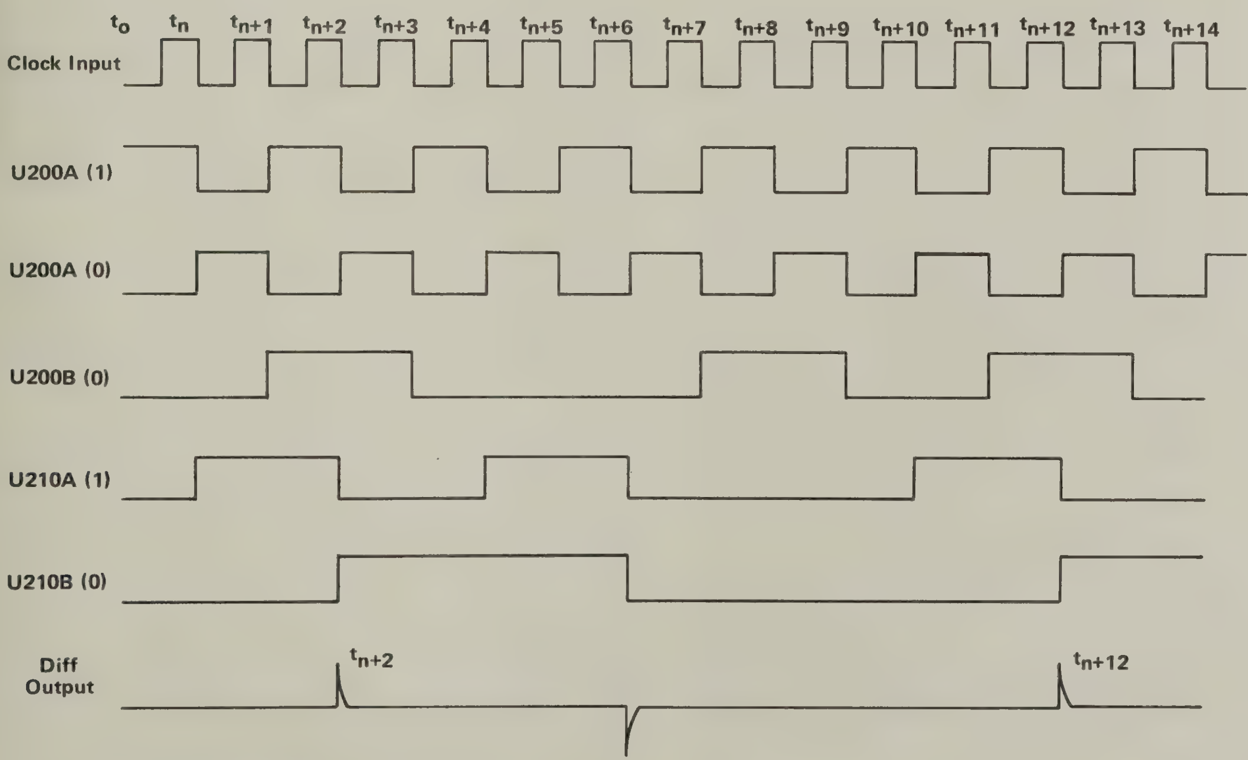


B. Ladder diagram.

Fig. 3-4. Logic and ladder diagram for the 10 μs to 50 μs dividers.



A. Logic diagram of decade counter in 50 μs to 5 s counters.



B. Waveform ladder diagram.

Fig. 3-5. Logic and waveform diagram for millisecond and second dividers.

4. U140B output state does not change because a high existed on the S and C inputs when the clock pulse arrived.

At $t_{n\ 4}$ the following occurs:

1. U120A is inhibited by the high on its S input from the 0 output of U140A. The 1 output U120A remains high.

2. U120B output remains high.

3. The 1 output of U140A flips high, because it has a high on its S input.

4. U140B will toggle because both inputs S and C are low. The first decade count has now started. The remaining sequence of events for the countdown operation is illustrated on the ladder diagram.

Fig. 3-4. illustrates both logic and waveform ladder diagrams for this divide by five counter. The sequence of operation is very similar to countdown of five by the .5 μs to 10 μs countdown circuit.

Millisecond and Second Dividers

Integrated circuits containing JK flipflops are also used in the countdown or divider circuits of this section. Dividers for each decade are identical; therefore, the description of one applies to any in the group. A logic diagram plus waveform ladder illustration are shown in Fig. 3-5.

The countdown of two for the even numbered marker selections is taken from the 1 output (pin 14) of the first JK flipflop in the decade counter. The JK toggles during the negative transition of the input clock pulse because its S and C inputs are both low. The countdown of five function is performed by the remaining JK flipflops in the counter.

The outputs from the counters are amplified by inverters and coupled through differentiating RC circuits, to the base of an emitter follower. The differentiator time constant is approximately 5% to 10% of the input square wave duty factor. The emitter follower is biased at its threshold of conducton, which clamps the negative portion of the differentiated waveform near ground. Only the positive portion of the input waveform appears at the output of the emitter follower. A summing resistor between the emitter and the MARKER SELECTOR switch permits markers to be stacked (more than one marker selected) at the marker output.

The waveform ladder diagram in Fig. 3-5 assumes an initial state at t_0 as follows: Output 1 (pin 14) of U200A high, output 0 (pin 8) U200B low, output 1 (pin 14) U210A low, and output 0 of U210B low. Any condition may be assumed if desired; however, after a few cycles the counter will assume a definite pattern. This waveform pattern illustrates the countdown action and is described as follows:

During the negative transition of the first clock pulse (t_n) the following events occur:

1. U200A toggles because both inputs (S and C) are low. The 1 output flops low and the 0 output flips to a high state.

2. The output state of U200B remains unchanged because the input signal to the "T" terminal was positive-going.

3. U210A toggles during the negative transistion of the 1 output from U200A. Inputs S and C are both low; therefore, 210A output flips to a high state.

4. U210B will not change because the clock input pulse transistion from U210A (1 output) is positive-going.

At $t_{n\ 1}$ the next negative transition of the clock pulse arrives and the following events occur:

1. U200A again toggles. The 1 output flips high and the 0 output steps low.

2. U200B now toggles because the clock pulse from the 0 output of U200A is negative going and its S input is held low by the 0 output (pin 8) of U210B. The 0 output of U200B steps high.

3. U210A and U210B hold their previous states.

With the arrival of the next clock pulse at $t_{n\ 2}$ the following events occur:

1. U200A again toggles.

2. U200B holds because its input signal from U200A is a positive-going transition at this time.

3. The C input to U210A is held high by the 0 output of U200B. Its 1 output will step low.

4. The negative-going transition from the 1 output of U210A toggles U210B. The 0 output of U210B steps high which generates the first step function from 0 output of U210B.

The counter has now cycled and is ready to perform its function as a countdown of two—countdown of five counter. The waveform ladder diagram illustrates the events as the countdown is performed.

Marker Amplifier and Selector Switching

This circuit contains the marker amplifier, the MARKER SELECTOR pushbutton switches, TRIGGER SELECTOR pushbutton switches and output amplifiers. These circuits supply time-markers and trigger signals to the front panel MARKER OUT and TRIGGER OUT connectors.

The trigger selector switches are dual contact, two position switches. One set of contacts closes the circuit between the marker generating circuit and the emitter follower output stage, while the other pair of contacts enables or disables the 50 ns (20 MHz) frequency multiplier and the marker amplifier.

Pushing any one of the .1 μs to 5 s pushbutton MARKER SELECTORS connects the —30 V supply through a voltage divider to the center tap of the coupling transformer T22, in the input circuit of the 50 ns (20 MHz) multiplier stage. The increased back bias disables the multiplier, and because the subsequent 10 ns, 5 ns, and 2 ns multipliers depend on the output of the 50 ns multiplier for their signal, they are also disabled.

With all of the .1 μs to 5 s selectors disengaged, back bias is removed from the transformer center tap and the

50 ns multiplier is enabled. All high frequency multipliers will now operate when the appropriate pushbutton selector is depressed.

The emitter circuit of input amplifier Q330 in the Marker Amplifier has no return through the switch to ground; therefore, the amplifier is disabled. Depressing either the .1 μs or .5 μs pushbutton applies back bias through R335 to the 5 ns multiplier, which disables the sine-wave multipliers. Input amplifier Q330, however, is still back-biased so the marker amplifier is held inoperative until a 1 μs or lower MARKER SELECTOR button is depressed.

When any selection of 1 μs or lower is made, the —30 V supply is applied through the + and — position of the MARKER AMPLIFIER selector switch S300 to the emitter of Q330. This forward biases the transistor and the amplifier circuit now operates to amplify selected time-markers to an amplitude of 25 V peak or more, into 1 kΩ load. Either positive or negative-going markers can be selected by the MARKER AMPLIFIER switch S340.

Marker intervals from 1 μs to 5 s, selected by MARKER SELECTOR switch S300, are applied through operational amplifier Q312 and Q317 to the base of input amplifier Q330. The amplified markers are then applied directly (as negative-going signals) or inverted by Q330 (for positive-going signals) to a complementary amplifier stage containing transistors Q345 and Q347. The complementary amplifier provides ample current output to drive the added capacitance of most coaxial cables that may be attached to the OUTPUT connector. The rise and fall-time of the time-marker pulse is thus preserved. The output markers from the emitters of the complementary amplifier are DC coupled to the OUTPUT connector for negative-going markers and AC coupled for positive-going markers. Diode CR348 is a DC restorer and clamps the output of the AC coupled signal near ground potential.

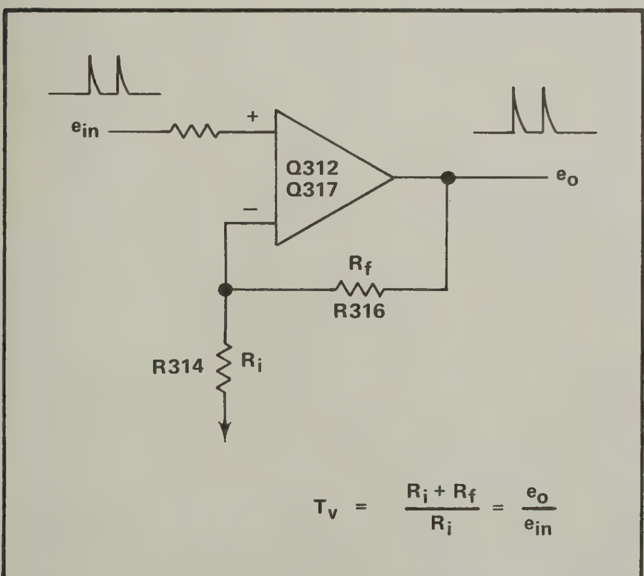


Fig. 3-6. Simplified diagram or equivalent circuit for the output amplifier for the .1 μs to 5 s time markers.

Input amplifier Q330 has a gain of approximately 25. Diode CR325 provides temperature compensation for transistor Q330.

The TRIGGER SELECTOR pushbuttons apply the .1 μs to 1 s markers, in decade steps, to the base of an emitter follower Q366. Q366 supplies the current drive for the TRIGGER OUT connector. Resistor R366, between the collector of Q366 and the +3.6 V supply, is a current limiting resistor.

The output amplifier (Q312 and Q317), for the .1 μs to 5 s time-markers, is configured as an operational amplifier to provide a low impedance current source for the MARKER OUT connector. Input signals to the base of Q312 are amplified, inverted and coupled directly to the base of Q317. The feedback loop for the operational amplifier is through R316 to the emitter of Q312 (see Fig. 3-6). Input impedance R_i is the emitter resistor R314. Feedback impedance R_f is the resistance of R316. Resistor R319 limits current through transistor Q312 if the MARKER OUT connector is accidentally shorted.

Power Supply

The power supply consists of two regulated DC voltages, —30 V and +3.6 V. Circuit details for the supplies are shown on the Power Supply diagram in Section 8.

Power for the regulator circuits is supplied from two full wave bridge rectifier power supplies connected across secondary taps of a single transformer, T403. These regulators will maintain a constant output with AC input fluctuations of 90 VAC to 136 VAC or 180 VAC to 272 VAC. The primary winding to T403 consists of equal windings which may be connected in parallel by S403 (LINE VOLTAGE selector) for 115 V AC or in series for 230 V AC input power.

A crystal oven is wired so it is not dependent on the POWER switch. Power is therefore applied to the heater of the 75° oven as long as the instrument is connected to a power source. The circuit for the OVEN indicating neon (DS 405) is complete when the thermal switch is closed. This neon indicates proper operation of the crystal oven thermostat and temperature stabilization of the crystal oven.

The voltage regulators are mounted on the divider board with the exception of the +3.6 V series regulator transistor. Q424 is mounted on the back panel heat sink.

—30 Volt Supply

—30 volts is the prime supply for the marker amplifier and the reference voltage for the +3.6 volt supply. The circuit consists of a comparator, Q436 and Q439, with its output driving a series regulator Q458.

Reference voltage for the —30 volt regulator is set by Zener diode VR432 in series with diode CR432 to ground. The voltage at the base of Q436 is approximately 10.6 volts. A voltage divider consisting of R452, R451 (—30 V adjust) and R450, connected between the —30 V buss and ground, supplies a sample of the —30 volts to the base

of Q439 (the other half of the comparator). When —30 V Adjust R451 is properly set, the output voltage from the supply is —30 volts. Any line voltage fluctuations or load current changes generate an error voltage signal from the comparator. This error voltage controls the bias of the pass transistor Q458 to compensate and correct the output for any change in current demand by the load.

+3.6 Volt Supply

This regulator consists of a comparator amplifier as the error sensing device, driving series regulator Q424 through emitter follower Q422 (Darlington amplifier). The common emitters of the comparator are returned through R415 to the —30 volt reference. A sample of the +3.6 volt supply is applied to the base of Q417 through the voltage divider R421 and R419. Any change or error in the 3.6 volt supply is amplified by the comparator and applied to the base of Q422. Q422 drives the base of Q424, in a Darlington amplifier configuration, to regulate current to the +3.6 volt output. This configuration provides an approximate current gain equal to the product of the two transistor beta's. See Fig. 3-7.

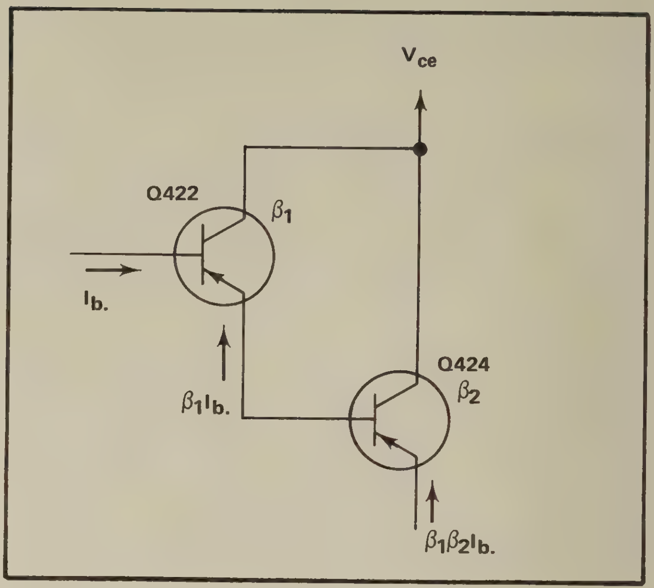


Fig. 3-7. Simplified drawing to illustrate current gain through the series regulator for the power supply.

SECTION 4
MAINTENANCE

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

This section describes recommended procedures for avoiding instrument malfunction, and provides troubleshooting procedure and corrective maintenance procedures to repair the instrument. Preventive maintenance improves instrument reliability. If the instrument should fail to function properly, corrective measures should be taken immediately; otherwise, additional problems may develop within the instrument.

Access to the Interior

Disconnect the power cord from the power source before removing the instrument covers. The top and bottom covers of the 2901 are removed by first turning each of the four latching screws a quarter turn counterclockwise to the stop, then lifting the cover off the instrument.

After the covers have been removed, the power cord may be reconnected to a power source, and the power switched ON.

Preventive Maintenance

Preventive maintenance consists of cleaning, visual inspection, performance check and (if needed), a calibration. The preventive maintenance schedule that is established for the instrument should be based on the expected operating environment and the amount of use planned for the instrument. Under average conditions (laboratory situation) a preventive maintenance check should be performed every 1000 hours of instrument operation.

Cleaning

Clean the instrument often enough to prevent dust or dirt from accumulating in or on it. Dirt acts as a thermal insulating blanket and prevents efficient heat dissipation, and if it becomes damp, it may provide electrical conducting paths or high resistance shorts.

Exterior. Clean the dust from the outside of the instrument by wiping or brushing the surface with a soft cloth or small brush. The brush will remove dust around the front panel selector buttons. Hardened dirt may be removed with a cloth dampened in water containing a mild detergent. Abrasive cleaners should not be used.

Interior. Clean the interior by loosening accumulated dust with a dry soft brush, then remove the loosened dirt with a vacuum cleaner or use low pressure dry air to blow the dust clear. High velocity air should not be used, because it may damage some components. Hardened dirt or grease may be removed with a cotton tipped swab or a soft cloth dampened with water that contains a mild detergent (such as Kelite or Spray White). Abrasive cleaners should not be used.

CAUTION

Be very careful, when cleaning around or near the multiplier coils, to avoid bending the coils. Distorted coils may drastically affect the performance of the multipliers. Do not permit water to get inside the switches or IC and transistor sockets. Avoid using chemical cleaners which might damage the plastics used in this instrument. Some chemicals to avoid are benzene, toluene, zylene, acetone or similar compounds.

Lubrication

A lubrication kit (Tektronix Part No. 003-0342-01) containing the necessary lubricant and instructions is available from Tektronix, Inc. Use Cramolin special lubricant or No Noise contact restorer on the pushbutton switches. Lubricate by injecting a drop into the rear of the switch body with the instrument standing on its front. This will allow the lubricant to seep forward to the switch contact. Lubricate only if the switch becomes noisy.

Visual Inspection

After cleaning, the instrument should be carefully checked for such defects as poor connections, damaged parts, and improperly seated transistors and integrated circuits. The remedy for most visible defects is obvious; however, if heat-damaged parts are discovered, determine the cause of over-heating before the damaged parts are replaced. Otherwise the damage may be repeated.

Transistor and Integrated Circuit Checks

Periodic checks of the transistors and integrated circuits are not recommended. The best measure of performance is the actual operation of the component in the circuit. Performance of these components is thoroughly checked during performance check or recalibration and any substandard transistors or integrated circuits will usually be detected at that time.

Performance Checks and Recalibration

To insure accuracy, the instrument performance should be checked after each 1000 hours of operation or every six

months if the instrument is used intermittently. The performance check and calibration procedure may assist in locating troubles which may not be apparent during regular operation. Instructions for conducting a performance check or calibration are provided in Section 5.

TROUBLESHOOTING

The ability to recognize and locate trouble is acquired through experience and familiarity with the instrument. The following describes a few aids that may assist in locating a trouble. After the defective component has been located, refer to Corrective Maintenance procedures for removal and replacement instructions.

Troubleshooting Aids

Diagrams. Complete circuit diagrams are provided on foldout pages in the Diagrams section. The component numbers and electrical values are shown on the diagrams along with significant voltages and waveforms. Each major circuit is assigned a series of numbers for the electrical components. Table 4-1 lists these circuits and the number series assigned. Circuits mounted on circuit boards are outlined with a dashed blue line.

NOTE

Corrections and modifications to the circuits are described on inserts bound into the rear of the manual. Check for changes to your instrument.

TABLE 4-1

COMPONENT NUMBERS

Component Number on Diagrams	Diagram Number	Circuit
1-99	1	Oscillator and Multipliers
100-199	2	μs Dividers
200-299	3	ms and s Dividers
300-399	4	Marker Amplifier and Selector Switching
400-499	5	Power Supply

Circuit Board Illustration. Each electrical component and test point is identified on pictorial circuit board illustrations at the end of this section. These illustrations together with circuit diagrams allow the troubleshooter to methodically trace the operation of each circuit.

Wiring Color Code. Color coded wire is used to aid circuit tracing. Power supply DC voltage leads have either a white background for positive voltage or a violet background for negative voltage. The EIA standard color code is used to signify the approximate voltage value of the wire. The widest stripe denotes the first significant figure.

Signal wires and cable use an identifying one-band or two-band color code.

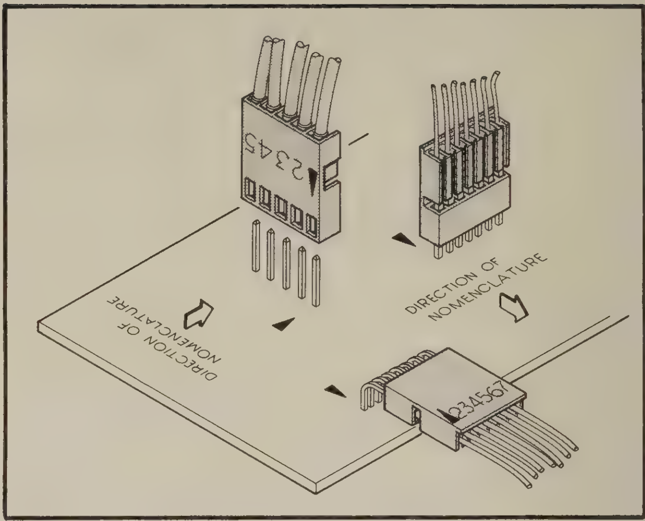


Fig. 4-1. Multiple pin connector plug orientation.

Multiple Terminal Connector Holders. Inter-circuit connections between the circuit boards, or between the boards and chassis mounted components, are made through pin connectors. The terminals in the connector holder are identified with numbers. Connector orientation to the circuit board is keyed with two triangles, one on the holder and one on the circuit board. See Fig. 4-1.

Resistor Color Code. Standard carbon composition and wire-wound high wattage or precision resistors are used in this instrument. The resistance values on all composition resistors are color coded with the EIA standard color code. The EIA color code for resistors and capacitors is shown in Fig. 4-2.

Capacitor Marking. The capacitance value of a common disc capacitor or small electrolytic is marked in microfarads on the side of the component body. The white ceramic capacitors are color-coded in picofarads using a modified EIA code. (Fig. 4-2).

Diode Color Code. The cathode end of each glass encased diode is indicated by a stripe, a series of stripes or dot. Fig. 4-3 illustrates polarity for the types of diodes used in this instrument.

Electrode Configuration for Socket Mounted Transistors and Integrated Circuits. Lead identification for the transistors and IC's is shown in Fig. 4-4.

General Procedure

The following procedure should facilitate troubleshooting and repair.

1. Be sure that there is really a malfunction in the instrument. Check operation of the associated equipment and the operating procedure of the 2901 (see Operating Instructions.

2. Determine and evaluate all trouble symptoms. Try to isolate the problem to a circuit or assembly. For example:

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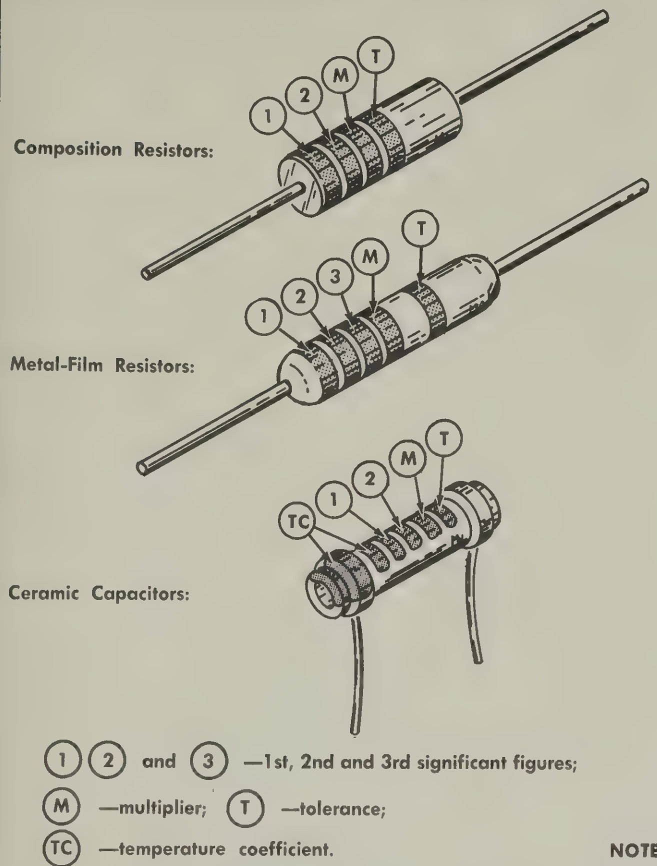

Resistor and Capacitor Color Code

Color	Significant Figures	Multiplier		Tolerance	
		Resistors	Capacitors	Resistors	Capacitors
Silver	---	10^{-2}	---	±10%	---
Gold	---	10^{-1}	---	±5%	---
Black	0	1	1	---	±20% or 2 pF*
Brown	1	10	10	±1%	±1% or 0.1 pF*
Red	2	10^2	10^2	±2%	±2%
Orange	3	10^3	10^3	±3%	±3%
Yellow	4	10^4	10^4	±4%	+100% −0%
Green	5	10^5	10^5	±0.5%	±5% or 0.5 pF*
Blue	6	10^6	10^6	---	---
Violet	7	---	---	---	---
Gray	8	---	10^{-2}	---	+80% −20% or 0.25 pF*
White	9	---	10^{-1}	---	±10% or 1 pF*
(none)	---	---	---	±20%	±10% or 1 pF*

*For capacitance of 10 pF or less.

NOTE: T and/or TC color code for capacitors depends upon manufacturer and capacitor type. May not be present in some cases.

Fig. 4-2. Standard EIA color coding for resistors and capacitors.

Markers present down to .1 ms but not below .1 ms, indicate the .1 ms to .5 ms counter (U200 or U210) is inoperative.

3. Visually inspect the area or the assembly for defects such as broken or loose connections, improperly seated components, overheated or burned components, chafed insulation or cracked insulators, etc. Repair or replace all obviously defective components. In case of overheated parts, try to determine the cause of overheating and correct before applying power.

4. Check power supply voltages, then circuit voltages and waveforms. The schematic diagrams contain pertinent voltages and waveforms for this purpose. Component location and test points are shown on circuit board call-outs at the end of this section (Fig. 4-9 and 4-10).

NOTE

Voltages and waveform illustrations on the diagrams are not absolute and may vary between instruments. The first diagrams page lists the conditions used to obtain the illustrations on the diagram.

When measuring voltages and waveforms, use extreme care in placing meter leads or probes. Because of high component density and the limited access within the instrument, an inadvertent movement of the leads or probe can cause a short circuit, producing transient voltages that may destroy many components.

5. Check calibration adjustments of the affected circuit, if applicable, such as one of the multipliers. Before changing an adjustment, note its physical position so it can be returned to this setting if it has no affect on the trouble. This will facilitate recalibration after locating and repairing the trouble.

If the trouble has not been found and corrected by the foregoing procedure, a more detailed analysis must be performed. The Circuit Description section describes the operational theory of each circuit and should aid in the evaluation of the problem.

Semiconductor failures account for a majority of electronic equipment failure. Because most semiconductor devices (transistors and IC's) are socket mounted, substitution is often the most practical means of checking their performance. The following guide lines should be followed when substituting these components.

1. Determine first that circuit voltages are safe for the substituted component so the replacement will not be damaged.

2. Use only components that are good.

3. Turn the power off before a component is substituted.

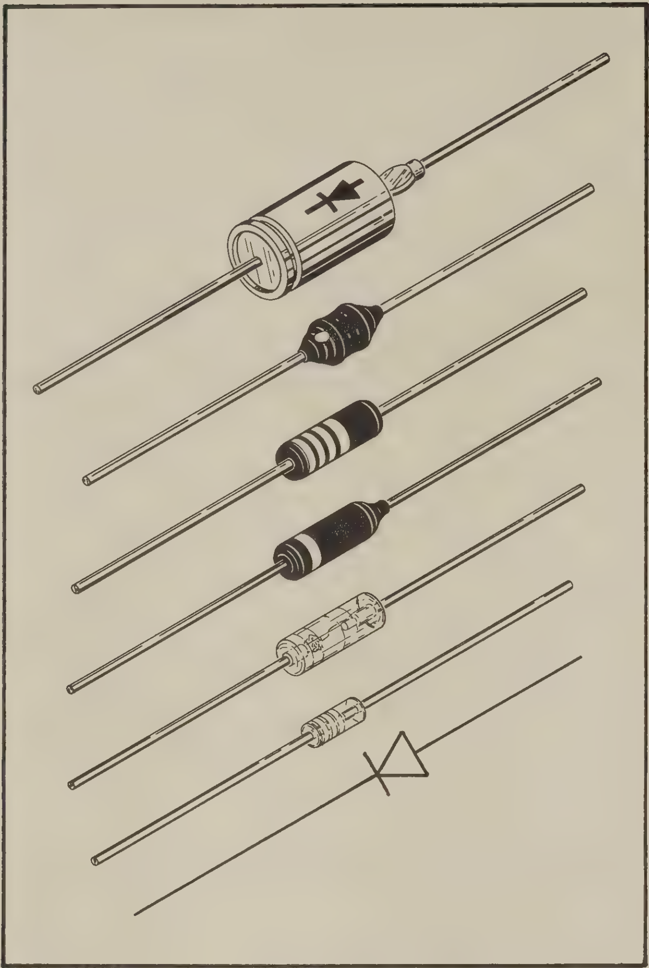

Fig. 4-3. Diode polarity markings.

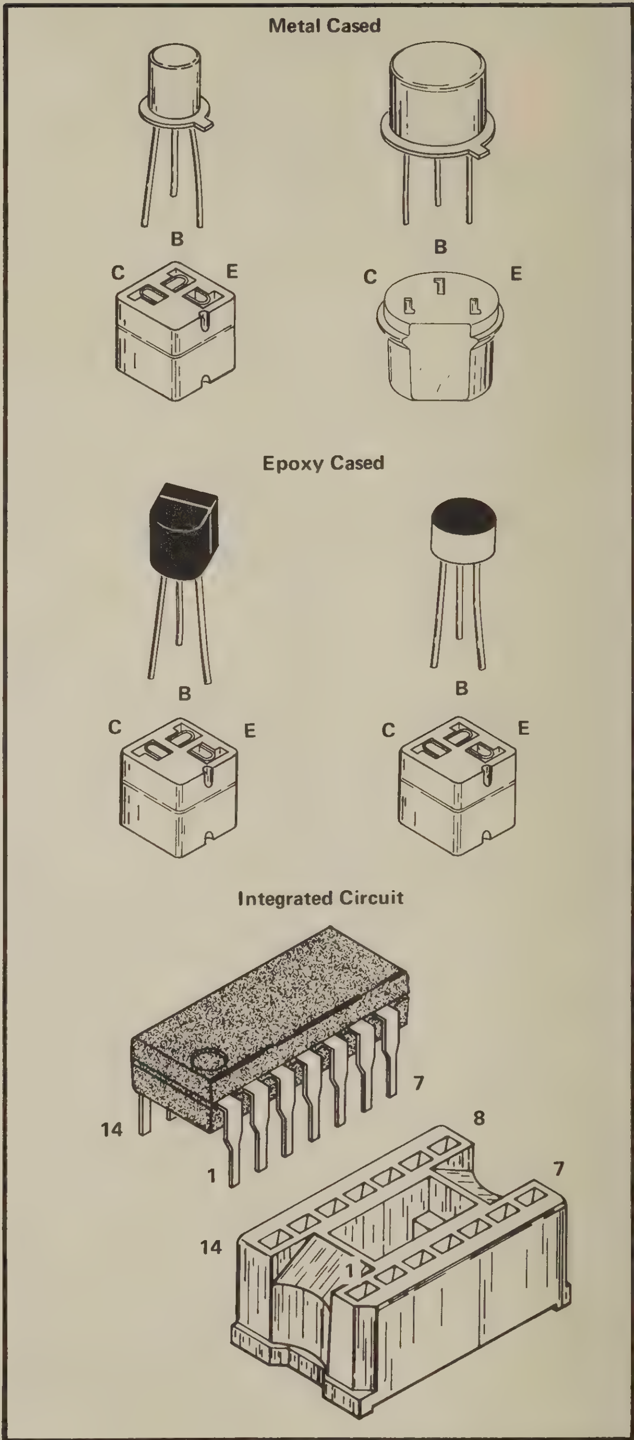

Fig. 4-4. Lead configuration for socket mounted transistors and IC's used in the 2901.

4. Be sure the component is inserted properly in the socket (see Fig. 4-4).

5. Return good components to their original sockets. This will reduce calibration time and run-in period.

6. Check calibration and performance after a faulty component has been replaced.

If a substitute is not available, check the transistor with a dynamic tester such as the Tektronix Type 576 Curve Tracer. Static type testers such as an ohmmeter can be used, if no other method is available, to check resistance ratios across the semiconductor junction. Use the high resistance ranges (R $\times$ 1 k or higher) so the external current is limited to less than 2 mA. If uncertain, measure the external current with an ammeter. Resistance ratios across the base to emitter junction or base to collector usually run 100:1 or higher. The ratio is measured by connecting the meter leads across the terminals, noting the reading, then reversing the leads and noting the second reading.

Return transistors to their original socket if they are satisfactory. Transistors with cooling radiators or heat dissipators (e.g. Q434) use a silicone grease between the heat dissipator and the transistor case to increase heat dissipation. Replace the silicone grease when the transistor is replaced.

WARNING

Silicone grease can cause severe eye irritation. Wash hands thoroughly after use. If eyes become

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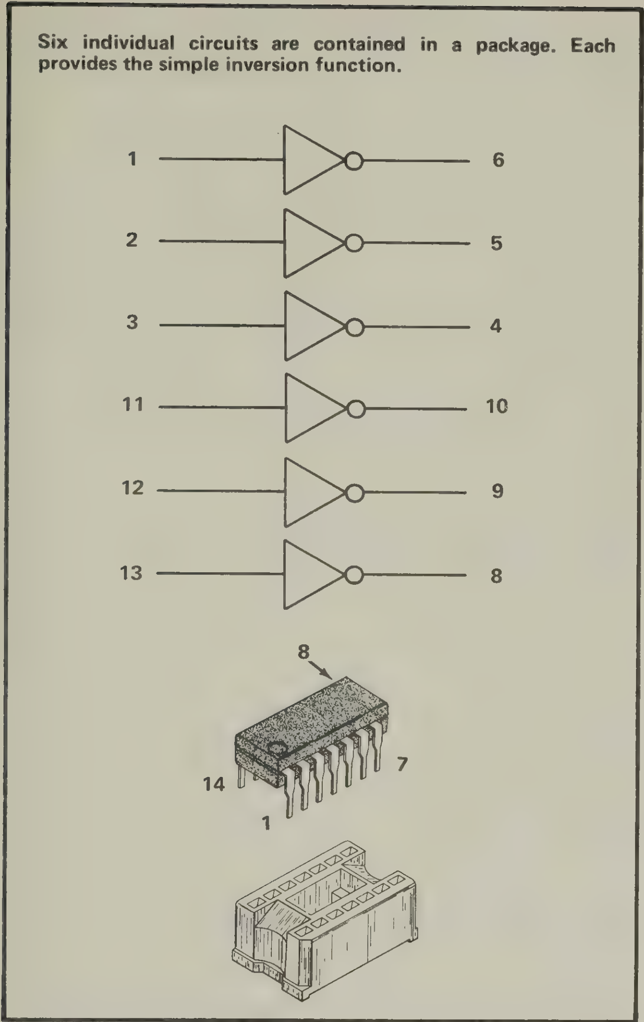


Fig. 4-5. Logic data for the 156-0021-00 (MC889) hex inverters.

contaminated, thoroughly flush the grease away with warm water and consult a medical facility.

Diode Checks—Most diodes can be checked in the circuit by taking measurements across the diode and comparing these with the voltages listed on the diagram. Forward-to-back resistance ratios can usually be taken by referring to the schematic and pulling appropriate transistors and pin connectors to remove low resistance loops around the diode. If necessary, unsolder one end of the diode and lift it clear so the ratio can be taken. Observe suggested soldering practices (using a heat sink) when soldering or unsoldering the diode.

CAUTION

Do not use an ohmmeter scale with a high external current to check the diode junction. (See transistor checks.)

Integrated Circuit (IC) Checks—Integrated circuits are most easily checked by direct replacement. When substitution is impossible, check input and output signal states as

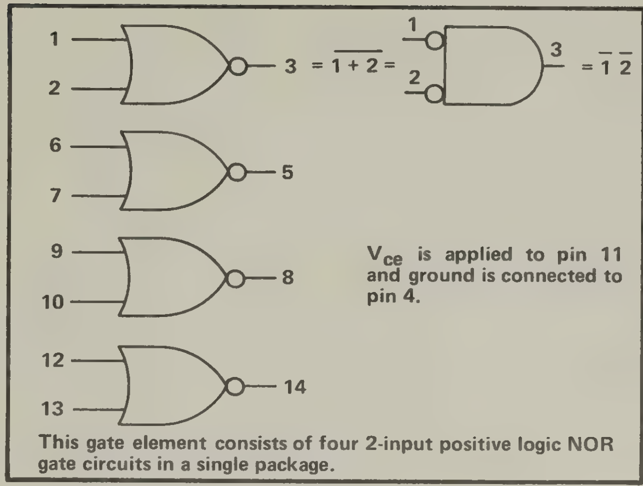


Fig. 4-6. Logic data for the 156-0020-00 (MC824P) four, 2-input NOR gates.

described in the circuit description and on the diagram. Lead configuration and data for the IC's used in this instrument are shown in Figs. 4-4 through Fig. 4-7.

CORRECTIVE MAINTENANCE

Corrective maintenance consists of component replacement and instrument repair. Special techniques or procedures required to replace components in this instrument are described here.

All replaceable electrical and mechanical parts can be obtained through your local Tektronix Field Office or representative. Many of the standard electronic components, however, can be obtained locally in less time than is required to order from Tektronix, Inc. Before purchasing or ordering replacement parts, consult the Parts List for value, tolerance and rating. The Parts section contains instructions on how to order these replacement parts.

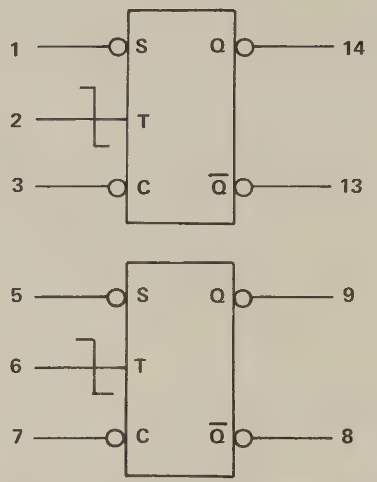
NOTE

When selecting the replacement part, it is important to remember that the physical size and shape of the component may affect its performance in the circuit.

It is best to duplicate the original component as closely as possible. Parts orientation and lead dress should also duplicate those of the original part because some components are oriented to reduce or control circuit capacitance and inductance. After repair, the circuits of the instrument may need recalibration.

Soldering Technique

This procedure is standard for most of Tektronix instruments and applies for most situations.



A. Logic diagram for MC891P and MC890P V_{ce} connected to pin 11. Pin 4 and all unused input pins are grounded.

The symbol ⎣ indicates this input is sensitive only to the negative transition of the signal.

Truth Table
(Clocked Input Operation)

t_n		t_{n+1}	
S	C	Q	$\overline{Q}$
H	H	Q_n	$\overline{Q}_n$
H	L	H	L
L	H	L	H
L	L	$\overline{Q}_n$	Q_n

B. The time period to the negative transition of the clock pulse is denoted t_n. The time period subsequent to this transition is denoted t_{n+1}.

Fig. 4-7. Data for the J-K flip-flop IC's used in the 2901. (In this instrument, pins 1 and 3, 13 and 14, are the reverse of the manufacturers data sheet.)

WARNING

Disconnect the instrument from the power source before soldering.

Circuit Boards. Use ordinary 60/40 solder and a 35- to 40-watt pencil type soldering iron on the circuit boards.

The tip of the iron should be clean and properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the wiring from the base material.

The following procedure is recommended to replace a component on a circuit board. Most components can be replaced without removing the board from the instrument.

1. Grip the component lead with long-nose pliers. Touch the soldering iron to the lead at the solder connection. (Do not lay the iron directly on the board; the heat may damage the board.)

2. When the solder begins to melt, pull the lead out gently. This should leave a clean hole in the board. If not, the hole can be cleaned by reheating the solder and placing a sharp object such as a toothpick into the hole. A vacuum-type desoldering tool can also be used for this purpose.

3. Bend the new component leads to fit the holes in the board. If the board is mounted in the instrument, cut the leads so they will just protrude through the board. Insert the leads into the holes in the board so the component is firmly seated or as it was positioned originally. If it does not seat properly, heat the solder and gently press the component into place.

4. To protect heat-sensitive components, hold the lead between the component body and the solder joint with a pair of long-nose pliers or other heat sink. Touch the iron to the connection and apply a small amount of solder to make a firm solder jonit.

5. Clip the excess leads (if not clipped in step 3) that protrudes through the board.

6. Clean the area around the solder connection with a flux remover solvent. Be careful not to remove information printed on the board.

Metal Terminals Soldering. When soldering metal terminals (e.g., switch terminals, potentiometers, etc.) ordinary 60/40 solder is satisfactory. The soldering iron should have a 40- to 75-watt rating and a ⅛ inch chisel tip.

1. Apply only enough heat to make the solder flow freely and form a good electrical connection. Do not use excessive solder. Excess solder may impair the operation of the circuit or cover a cold solder joint.

2. Clip off exccess wire that may extend past the soldered connection and clean the area with flux-remover solvent.

Replacing the Square Pin Circuit Board Terminals

The following describes the replacement procedure for circuit board pin connector replacement:

It is important not to damage or disturb the ferrule when removing the old stub or a broken pin. The ferrule is swaged into the circuit board and provides a base for soldering the pin connector.

If the broken stub is long enough, grasp it with a pair of needle nose pliers, apply heat with a small soldering iron to the pin base or the ferrule and pull the old pin out. (The pin is pressed into the ferrule so a firm pull is required to pull it out.)

If the broken stub is too short to grasp with pliers, use a small dowel (.028 inch in diameter) clamped in a vise to push the pin out of the ferrule after the solder has been heated.

The old ferrule can be cleaned by reheating the solder and placing a sharp object such as a toothpick or small dowel into the hole. A .031-inch drill mounted in a pin vise may also be used to ream the solder out of the old ferrule.

Use a pair of diagonal cutters to remove the ferrule from the new pin, then insert the pin into the old ferrule, and solder the pin to both sides of the ferrule.

If it is necessary to bend the new pin, grasp the base of the pin with needle nose pliers and bend against the pressure of the pliers to avoid breaking the board around the ferrule.

Pushbutton Switch Replacement

The pin connectors for the MARKER SELECTOR or TRIGGER SELECTOR switches are soldered into either of the two circuit boards. The complete switch assembly should be replaced if any switch is inoperative. Removal procedure is as follows:

1. Pull the pushbutton knobs.

2. Remove the circuit board assembly as described under Circuit Board removeal.

3. Unsolder the switch pin connectors and pull the solder from the pin board eyelet or ferrule with a desoldering tool. When all connections have been unsoldered and as much of the solder removed from the eyelet as possible, gently work the switch assembly loose from the board. This can be done by maintaining pressure between the switch assembly and the board as the soldering iron is applied briefly to each connection.

Lever Switch Replacement

Individual parts of a lever switch are usually not replaced. If a section of the switch is defective, replace the complete assembly. Refer to the Electrical Parts List for the correct part number to reorder the replacement. Tag the leads and switch contacts with corresponding tags or use the old switch assembly as a sample for wiring the replacement. Use soldering techniques previously described.

Circuit Board Replacement

Most of the components mounted on the circuit boards can be replaced without removing the circuit boards. Observe the soldering precautions listed under Soldering Techniques in this section. If the circuit board is damaged or the pushbuttons must be replaced, the following procedure describes how to remove these boards. Part Numbers for each board (complete assembly or boards only) are given in the Mechanical Parts List (Section 6).

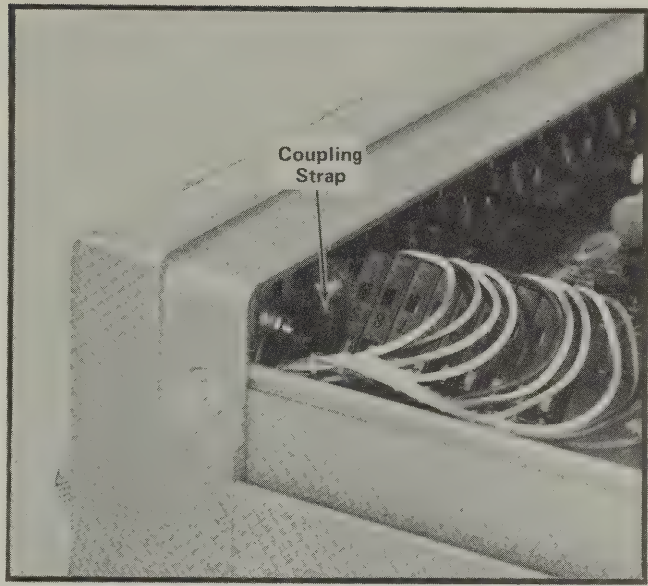


Fig. 4-8. Coupling strap between marker selector switch extrusion bar.

1. Upper (Multiplier) Circuit Board

a. Disconnect the pin connectors from the board and unsolder all soldered connections to the board. Tag each wire as to its connection as it is removed.

b. Remove the pushbutton by pulling straight out on the button.

c. Remove the four screws that hold the circuit board in place.

d. Remove the screw holding the top of the coupling strap between the upper and lower switch extrusion bar, see Fig. 4-8.

e. Slide the upper circuit board back and out of the instrument.

f. Replace the board by reversing the removal procedure.

2. Lower (Divider) Circuit Board

a. Disconnect the pin connectors from the board.

b. Pull the switch buttons off by pulling straight out.

c. Remove the four mounting screws that hold the circuit board.

d. Slide the board back and out of the instrument.

e. Replace the board by reversing the removal procedure.

f. Refer to Fig. 4-1 if in doubt about pin connector orientation.

Miscellaneous Maintenance Information

The power transformer in this instrument is warranted for the life of the instrument. If defective, contact your local

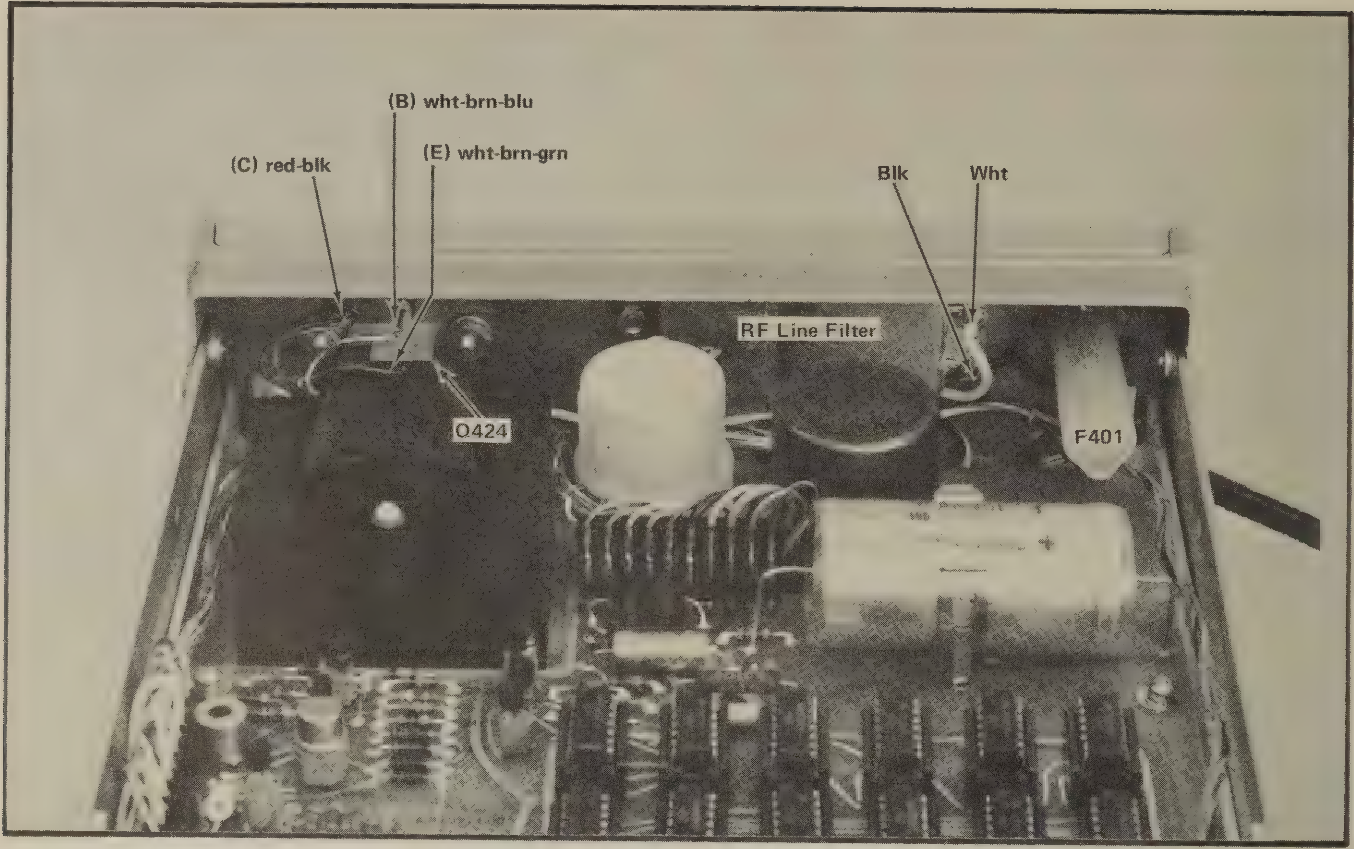


Fig. 4-9. Location and installation of the optional RF line filter.

Tektronix Field Office or representative (see warranty note in front of this manual). Use only a direct replacement Tektronix transformer. Be sure to label the leads before unsoldering them from the transformer terminals.

Fig. 4-9 illustrates the location and installation of an optional RF line filter.

Recalibration After Repair

When any electrical component is replaced, the calibration and performance of the associated circuit must be checked as well as other dependent circuits. If the power supply has been repaired, all circuits are affected and their performance should be checked using the procedure described in Section 5.

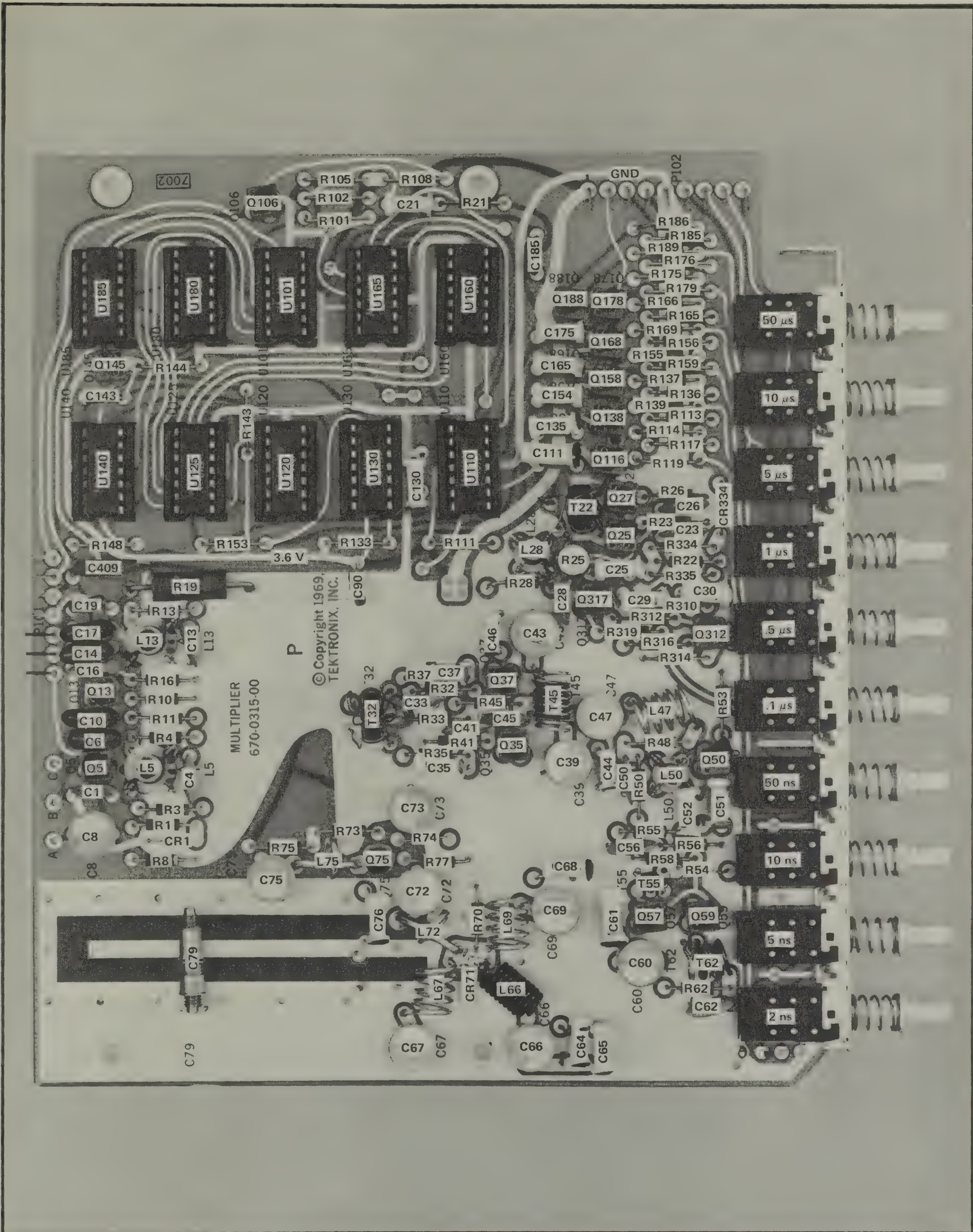


Fig. 4-10. Component location for the multiplier circuit board (oscillators, multipliers, and μs divider circuits).

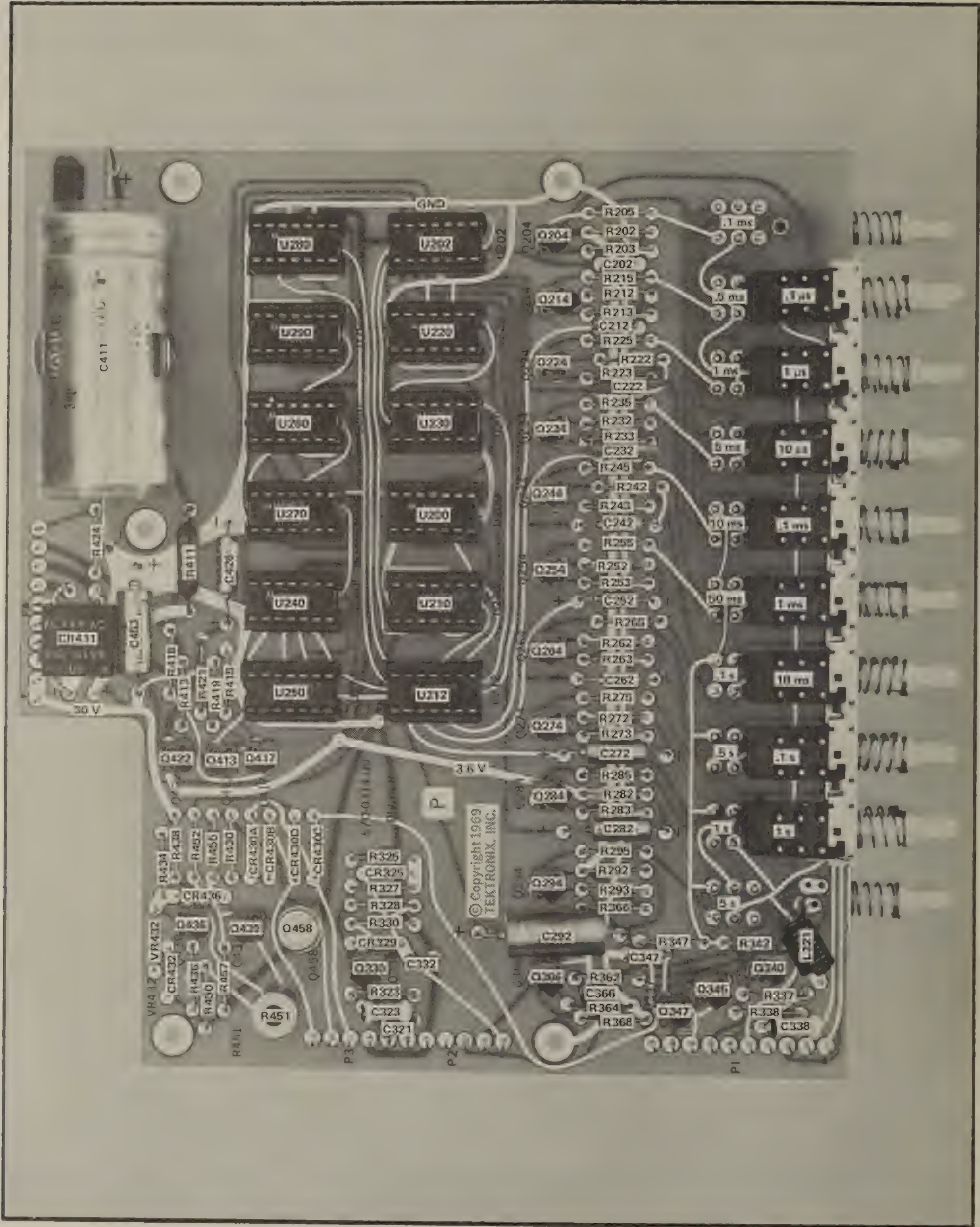


Fig. 4-11. Component location for the divider circuit board (ms and s dividers, power supply regulator, and trigger output circuits).

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SECTION 5
PERFORMANCE CHECK/CALIBRATION

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

This section is a composite of two procedures. One provides a front panel check of instrument performance against specifications outlined in Section 1 and the second describes complete calibration of the instrument. Performing the complete procedure, checks and restores the instrument to original performance standards. The equipment listed is needed for both a Performance Check and Calibration. Equipment setup pictures, control settings and most waveform photographs apply to both procedures.

Limits, tolerances and waveforms provided in the calibration steps are furnished as guides and are not intended as instrument specifications. For example: power supply voltages and ripple tolerances listed in this procedure are guides to obtain optimum instrument operation. Actual values may exceed the listed tolerances with no loss in instrument performance.

Complete or Partial Performance Check

Perform all steps in sequence without removing the side panels or covers. All performance requirements given in this section correspond to the characteristics given in the Specification section. Internal calibration adjustment steps or checks are preceded with ADJUST. These steps are not part of the performance check procedure.

After replacing a component or repairing a circuit, if a partial performance check is desired, refer to the nearest test equipment setup that precedes the desired check step. This will list the initial equipment setup and control positions. Then make the necessary changes described in the steps between initial setup and the desired partial check.

Complete or Partial Calibration

Before performing a complete calibration, the instrument should be cleaned and inspected as outlined in the Maintenance Section. Perform all checks and adjustments in sequence. Internal checks such as power supply regulation are preceded or followed with a NOTE indicating that these checks are only applicable to calibration.

A partial calibration can be performed by turning to the check or calibration desired and following the procedure described for a partial performance check.

History Information

The instrument and manual are subjected to constant evaluation and updating. Consequently circuits and performance/calibration procedures are modified. The history of procedure and information applicable to earlier instruments are included either as deviations within the steps or as a sub-part of a step. These are clearly indicated.

Interaction

Adjustments that interact are noted and referenced to the affected step or steps.

Equipment and Test Fixtures Required and Recommended

The following is a list of equipment required to perform a complete performance check or calibration. The specifications given are minimum for accurate calibration; therefore, some of the recommended equipment specifications may exceed these minimum requirements.

Special Tektronix calibration fixtures are also used to facilitate the procedure. These fixtures are available from Tektronix, Inc. and may be ordered through your local Tektronix Field Office or representative.

If a partial performance check or calibration is desired, the necessary test equipment to perform these checks and adjustments can be determined by referring to the appropriate steps in the procedure.

1. Test oscilloscope: Bandwidth DC to 10 MHz real time and DC to 500 MHz equivalent time; deflection factor, .01 V/Div; sweep rate 5 s/Div to 2 ns/Div. Tektronix Type 561 or 564 oscilloscope with Type 3S1 and Type 3T77A Sampling plug-in units, plus Type 3A6 amplifier and Type 2B67 real time plug-in units; Tektronix Type 540 series with Type 1A1 amplifier plug-in unit plus Type 1S1 sampling plug-in unit; or 7000 series oscilloscope with 7A16, 7B70 and 7S11, 7T11 plug-in units.

2. 1× probe: Tektronix P6011 with BNC connector. Tektronix Part Number 010-0192-00.

3. 10× probe: Tektronix P6034 with GR connector (for sampling unit). Tektronix Part Number 010-0110-00.

4. Variable autotransformer: Variable range 90 VAC to 136 VAC or 180 VAC to 272 VAC. General Radio Metered Variac Autotransformer, Model W10MT3W. If autotransformer does not have an AC voltmeter to monitor the output voltage, an AC voltmeter (RMS) with a range 90 to 272 volts must be used.

5. Frequency Standard or Digital Frequency Counter: Frequency 10 MHz; stability 0.3 P/M[1] over any 24 hour period. Hewlett-Packard HP 5245L counter recommended.

A stable communications receiver that will receive any one of the National Bureau of Standards transmitting stations (WWV, WWVB, WWVH) can also be used to check the accuracy of the internal clock frequency.

6. DC voltmeter: Sensitivity 20,000 ohms/volt, accuracy within 1% at 30 volts and 3.6 volts.

7. Signal Generator: Frequency range 350 kHz to 10 MHz. Output amplitude 2 V peak to peak into 50 Ω. Tektronix Type 191 Constant Amplitude Signal Generator.

8. Pulse Generator: Frequency range 50 kHz or less to 350 kHz. Output pulse amplitude 2 V peak into 50 Ω. Pulse risetime faster than 2 V/μs. Tektronix Type 115 Pulse Generator.

9. Termination: Impedance 50 Ω, BNC connectors. Tektronix Part Number 011-0049-01.

10. Adapter: GR to BNC female. Tektronix Part Number 017-0063-00.

11. Adapter: Clip-lead to BNC. Tektronix Part No. 013-0076-00.

12. Adapter: BNC to dual binding post. Tektronix Part No. 103-0035-00.

13. Cables: Two (2), impedance 50 Ω, Type RG58A/U, length 42 inches, BNC connector. Tektronix Part No. 012-0057-00.

14. Resistor: 1 kΩ, ½ watt, 1% tolerance. Adjusting Tools (see Fig. 6-2).

15. Alignment Tools:

a. Small screwdriver with a 3/32 inch blade.

b. Low-capacitance alignment tool and handle, for tuning 5/64 inch hex slugs. Tektronix Part Number 003-0307-00 Insert Tektronix Part Number 003-0310-00.

c. Low-capacitance alignment tool, to tune ⅛ inch powdered iron cores. Tektronix Part Number 003-0497-00.

PERFORMANCE CHECK/CALIBRATION RECORD AND INDEX

The following abridged performance check and calibration procedure provides a record of the performance check and/or calibration or it may be used as a guide for an experienced calibrator. It may also serve as an index to locate a particular step in the procedure. Performance requirements, given in the following steps, correspond to those given in Section 1.

Short Form Procedure

2901, Serial No. ______________________

Calibration Date ______________________

Calibrator ______________________

☐ 1. Check Oven Light Operation — Page 5-3

REQUIREMENT—Oven should cycle on and off at regular intervals; on approximately 10 seconds and off 20 to 30 seconds.

PERFORMANCE—ON ________, OFF ________.

☐ 2. Check/Adjust—30 Volt Supply (Calibration Only) — Page 5-4

REQUIREMENT—30 Volts ±5%,

PERFORMANCE—Voltage ________

☐ 3. Check Power Supply Voltage Regulation and Ripple (Calibration Only) — Page 5-4

REQUIREMENT—3.6 V ±5%. Ripple within 40 mV
—30 V ±5%, Ripple within 40 mV

PERFORMANCE—3.6 V ± ____, Ripple ____ mV
—30 V ± ____, Ripple ____ mV

☐ 4. Check/Adjust Crystal Oscillator Frequency. Check stability. — Page 5-5

REQUIREMENT—Accuracy within 10 P/M of 10 MHz standard from 20°C to 30°C. Stability within 3 P/M from 20°C to 30°C.

PERFORMANCE—Accuracy ____. Stability ____.

☐ 5. Check/Adjust 50 ns Marker Output — Page 5-8

REQUIREMENT—Accuracy within 10 P/M, amplitude at least 0.5 V peak into 50 Ω.

PERFORMANCE—Accuracy ____ Amplitude ____V peak.

☐ 6. Check/Adjust 10 ns Marker Output — Page 5-9

REQUIREMENT—Accuracy within 10 P/M, from 20° C to 30° C, Amplitude at least 0.3 V peak into 50 Ω load.

PERFORMANCE—Accuracy ____ Amplitude ____V peak.

☐ 7. Check/Adjust 5 ns Marker Output — Page 5-9

REQUIREMENT—Accuracy within 10 P/M from 20° C to 30° C, Amplitude at least 0.3 V peak into 50 Ω load.

PERFORMANCE—Accuracy ____ Amplitude ____V peak.

☐ 8. Check/Adjust 2 ns Marker Output — Page 5-9

REQUIREMENT—Accuracy within 10 P/M from 20° C to 30° C Amplitude at least 0.3 V peak into 50 Ω load.

PERFORMANCE—Accuracy ____ Amplitude ____.

☐ 9. Check Marker Output (.1 μs to 5 s) — Page 5-10

REQUIREMENT—Accurate marker periods. Amplitude of markers at least 0.5 V peak into 50 Ω load.

PERFORMANCE—Marker Periods; Correct ____ Incorrect ____. Amplitude for all markers ____V peak.

☐ 10. Check Marker Amplifier Output — Page 5-12

REQUIREMENT—Either positive or negative going markers for each Marker selection, from 1 μs to 5 s. Amplitude at least 25 V peak into 1 kΩ load.

PERFORMANCE—Correct polarity ____; incorrect polarity ____. Amplitude ____V peak into 1 kΩ.

☐ 11. Check Trigger Output (.1 μs to 1 s) — Page 5-12

REQUIREMENT—Accurate trigger periods. Amplitude of trigger signals at least 0.5 V peak into 50 Ω.

[1]Parts per million.

PERFORMANCE—Marker Periods; Correct _____ Incorrect _____. Amplitude _____V peak into 50 Ω.

☐ 12. Check External Oscillator Input Page 5-13

REQUIREMENT—Amplitude, 1 V peak to peak to 5 V (Peak AC + DC), Frequency 50 kHz or less to 10 MHz or more.

PERFORMANCE—Amplitude _____. Frequency range; correct _____ incorrect _____.

PERFORMANCE CHECK/CALIBRATION PROCEDURE

Preliminary

The sequence of steps in this procedure allows the 2901 to be calibrated or checked with the least interaction of adjustments and reconnection of equipment. The adjustment steps are identified by the symbol ◐ following the title. Performance requirements are checked in the "CHECK" part of the step before an adjustment is made. The "ADJUST part of the step identifies the calibration steps. Each step or group of similar steps is preceded by a test equipment setup figure to show the equipment and hookup required for each group of steps. Control settings and hookup changes throughout the procedure follow from the preceding step(s) unless nated otherwise. Front panel control titles that pertain to the 2901 are capitalized (e.g. MARKER SELECTOR). Internal adjustments and control callouts for associated test equipment are initial capitalized (e.g. —30 V Adjust, Time/Div).

The performance of the 2901 should be checked in an ambient temperature between 0°C and 50°C after the oven indicator shows the crystal has reached operating temperature (power cord connected to power source for a minimum period of 2 hours) and the POWER switch has been on for at least 5 minutes. Calibrate the instrument when the ambient temperature is within 25°C ±5°C, for best performance.

Waveform illustrations in this procedure are actual photographs taken with a Tektronix Oscilloscope Camera System. These pictures are intended to help clarify written descriptions within the steps and are not intended as adjustment objectives. Circuit modifications and variations between instruments can affect the wave shape, making it impractical to duplicate the photograph in the manual.

Performance Check Only

1. Set the LINE VOLTAGE selector (rear panel) to the appropriate settings (90-136 V or 180-272 V) for the available power source and the CLOCK switch to INT. Plug the 2901 power cord into the power source. Allow ample time for the instrument and crystal oven to stabilize.

2. Start the performance check with step 1 or turn to the desired step. (It may be necessary to refer to preceding steps for initial test equipment setup and control settings.)

Calibration Procedure Only

1. Remove the 2901 from its cabinet.

2. Connect the autotransformer to a suitable power source.

3. Set the LINE VOLTAGE selector (on the back panel) for the correct operating position (90-136 V or 180-272 V). Switch the CLOCK selector to INT position.

4. Connect the 2901 power cord into the output connector of the autotransformer and set the output of the autotransformer to 115 V (or 230 V).

5. Allow 2 hours, with power applied, for the crystal oven temperature to stabilize. Allow 5 minutes warmup time, after the crystal oven has stabilized, with power switched ON, before checking or adjusting any instrument parameters.

6. Begin the calibration procedure with step 1 or turn to the desired step. (It may be necessary to refer to preceding steps for initial test equipment setup and control settings.)

1. Check Oven Light

a. No test equipment is required for this check.

b. After 2 hour period with power applied the oven light should cycle on and off at regular intervals. (Typically on 10 s, off 35 s.)

NOTES

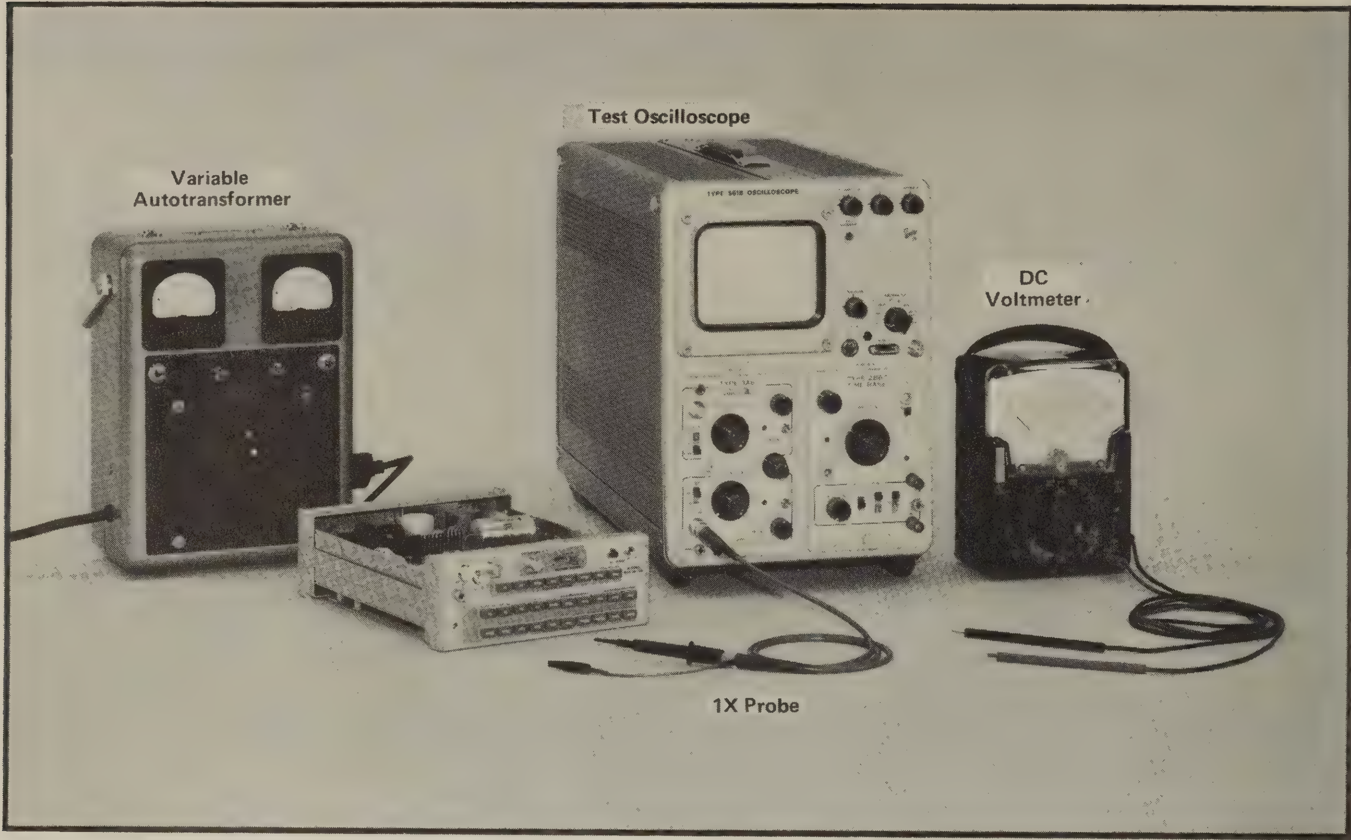


Fig. 5-1. Initial equipment setup for checking and adjusting power supply.

2. Check/Adjust —30 Volt Supply (calibration only)

a. Equipment setup is shown in Fig. 5-1.

b. Connect the DC voltmeter between the —30 V buss or terminal and chassis ground (see Fig. 5-2).

c. ADJUST —30 Volt Adjust R451 (Fig. 5-2) for —30 volts.

d. Interaction—May affect performance of all circuits within the 2901.

3. Check Power Supply Voltage Regulation and Ripple (Maintenance requirement only, not a specification.)

a. Test equipment setup is shown in Fig. 5-1.

b. Connect the DC voltmeter and the 1X probe from the test oscilloscope to the —30 volt buss (see Fig. 5-2).

c. Check—Voltage regulation and ripple amplitude of the regulated supply as the input supply voltage is varied between 90 VAC to 136 VAC (or 180 VAC to 272 VAC). Voltage should maintain —30 V ±5%. Ripple should not exceed 40 mV. Disregard high frequency hash, spikes or transients.

d. Connect the DC voltmeter and the test oscillscope probe to the +3.6 V buss or terminal (Fig. 5-2).

e. Check—Voltage regulation and ripple of the 3.6 V regulated supply using the procedure described in step c. Voltage should remain 3.6 V ±5%. Ripple should not exceed 40 mV.

f. Return the autotransformer to 115 (230) VAC and remove the 1X probe. If the line voltage is approximately 115 V (230 V), the 2901 may be connected directly to the line for the remainder of the procedure.

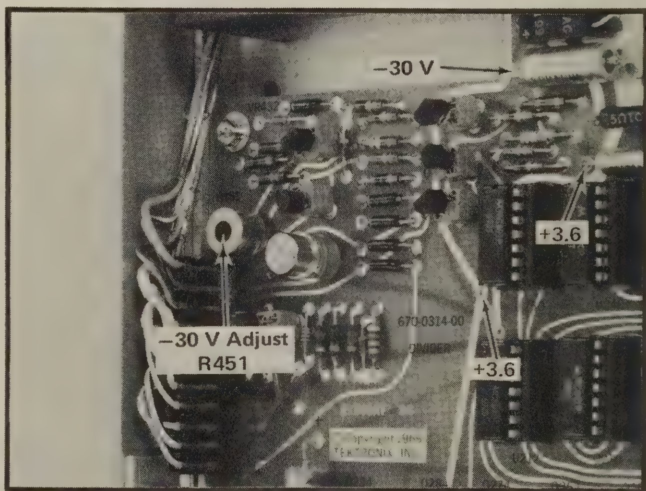


Fig. 5-2. Power supply voltage test points and adjustments.

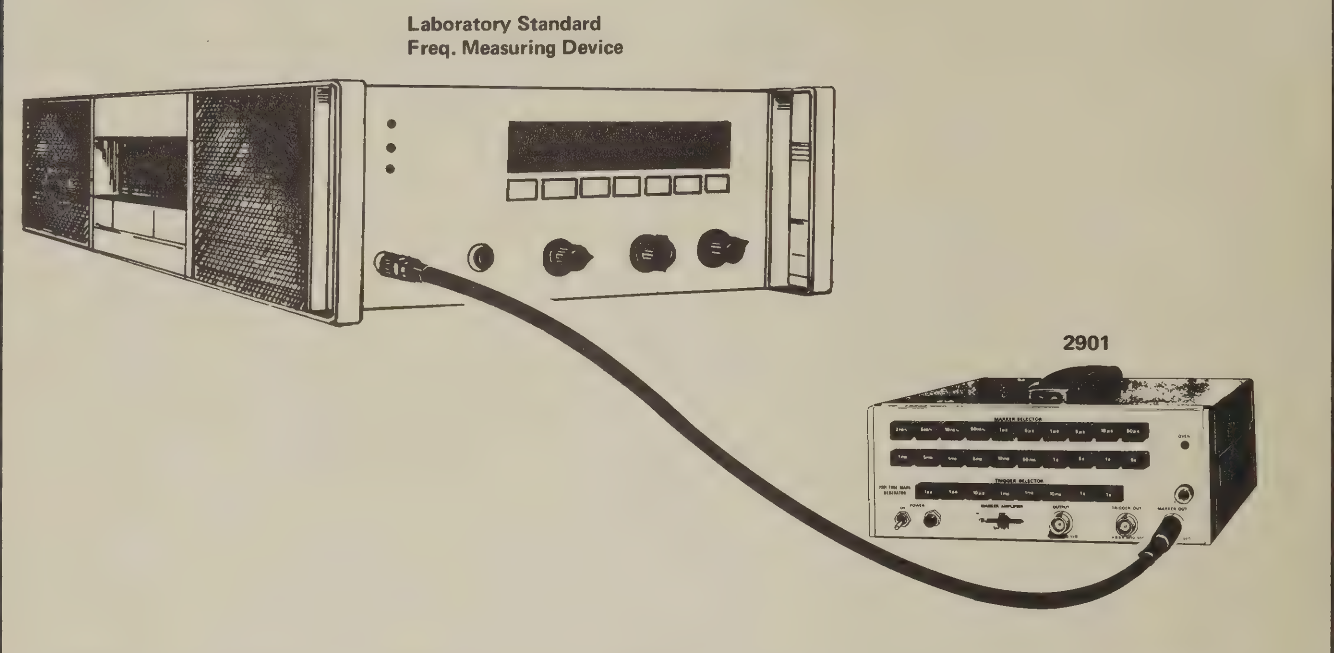
4. Check/Adjust Crystal Oscillator Frequency and Stability

An accurate 10 MHz frequency standard or measuring device is required to check or adjust the crystal oscillator frequency. Two procedures are provided. The first is a direct frequency measurement using an Electronic Digital Frequency Counter, the second procedure uses the National Bureau of Standards signal from their Boulder, Colorado (WWVB), Washington, D.C. (WWV), or Hawaii (WWVH) transmitting stations.

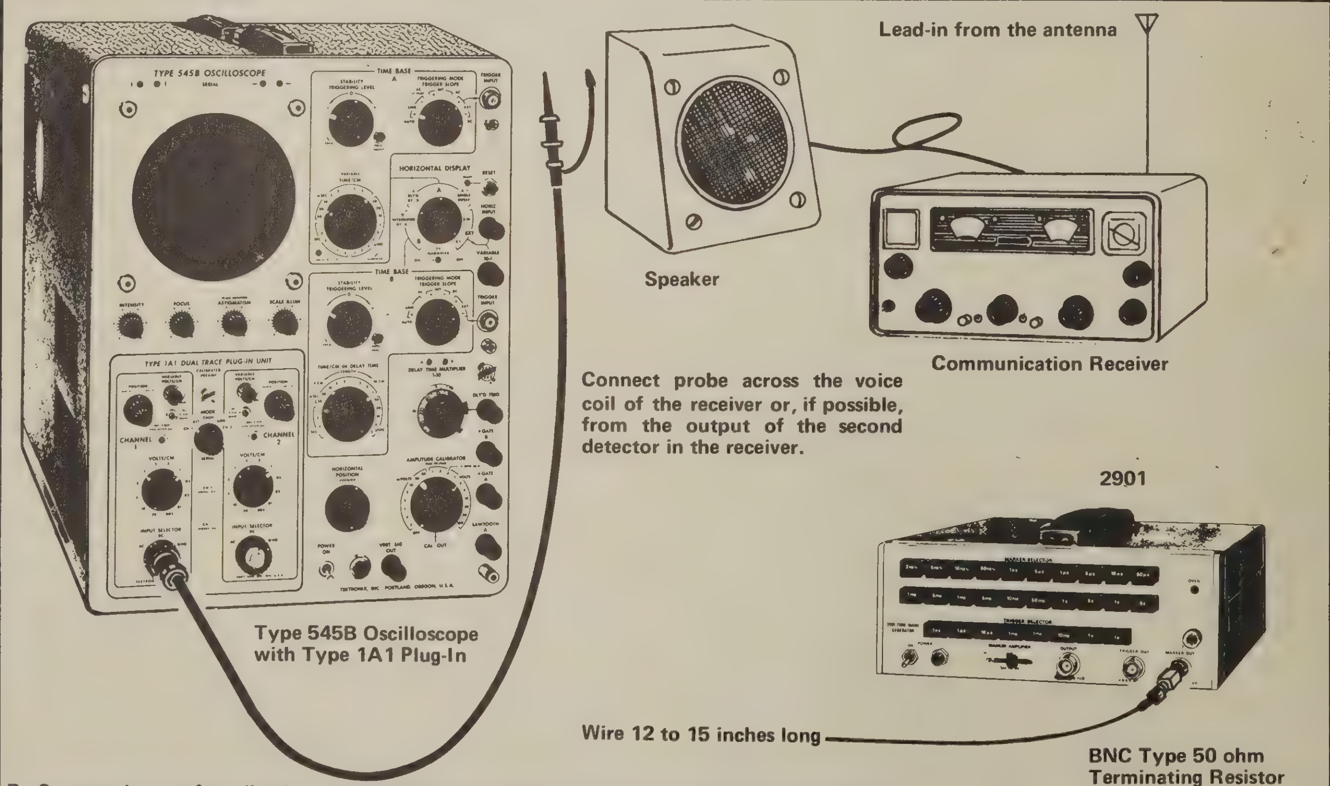
NOTE

Allow a minimum of 2 hours with power applied for the crystal oven to stabilize, before attempting to measure or adjust the oscillator frequency.

NOTES



A. Suggested setup for adjusting crystal oscillator to laboratory standard.



B. Suggested setup for adjusting crystal oscillator frequency to National Bureau of Standards.

Fig. 5-3. Equipment setup to check/adjust crystal oscillator frequency and stability.

Method 1

a. Test equipment setup is shown in Fig. 5-3A.

b. Requirement—Frequency 10 MHz ±100 Hz, when ambient temperature is within 20°C to 30°C; 10 MHz ±200 Hz for ambient temperature of 0°C to 50°C. The crystal oven must be stabilized. Frequency must not change more than 30 Hz/24 hour period (ambient temperature 20° C to 30° C).

c. Apply .1 μs markers from the MARKER OUTput connector of the 2901 through a coaxial cable and 50 Ω termination to the input connector of a digital frequency counter or equivalent frequency measuring device.

d. CHECK—Accuracy of the 10 MHz crystal oscillator and oscillator frequency stability.

e. ADJUST—Oscillator frequency to 10 MHz as follows:

1) Adjust C8 (Fig. 5-4) for 10 MHz.

2) Adjust L5 midway between oscillator dropout points. (To locate the dropout points, turn the core in until the oscillator stops, then turn the core out until the oscillator stops. Adjust the core to the center of the range.)

3) Adjust C8 for equal drift around 10 MHz, as the oven cycles on and off. L5 may be adjusted a slight amount (not to exceed ½ turn) for fine frequency shift.

f. Disconnect the .1 μs marker signal from the frequency measuring device and connect the MARKER OUTput through a 50 Ω termination to the vertical input of the test oscilloscope. Adjust the test oscilloscope Time/div and Volts/div controls for a .1 μs marker display on the oscilloscope. (1 μs/div to .1 μs/div settings are satisfactory.)

g. ADJUST—L13 (Fig. 5-4) for maximum marker amplitude. If the core of L13 is moved more than one full turn, readjust L5 to the midpoint of the oscillator operating range. Recheck accuracy of the 10 MHz oscillator.

h. Interaction—Will affect accuracy of all markers and trigger signals.

Method 2

a. Test equipment setup is illustrated in Fig. 5-3B. There is no direct connection between the 2901 and either test equipment.

b. Requirement—See step b, for Method 1.

c. Trigger the test oscilloscope internally from the signal input to the vertical plug-in unit.

d. The 10 MHz crystal oscillator can be checked or calibrated by beating the oscillator frequency against the National Bureau of Standards broadcast frequency. Check the frequency of the oscillator as follows:

1) Tune the communications receiver to the 10 MHz or 20 MHz NBS carrier signal, whichever is stronger. The National Bureau of Standards transmits a 440 or 1000 Hz tone for a part of each minute then a series of clock pulses or clocks, one each second.

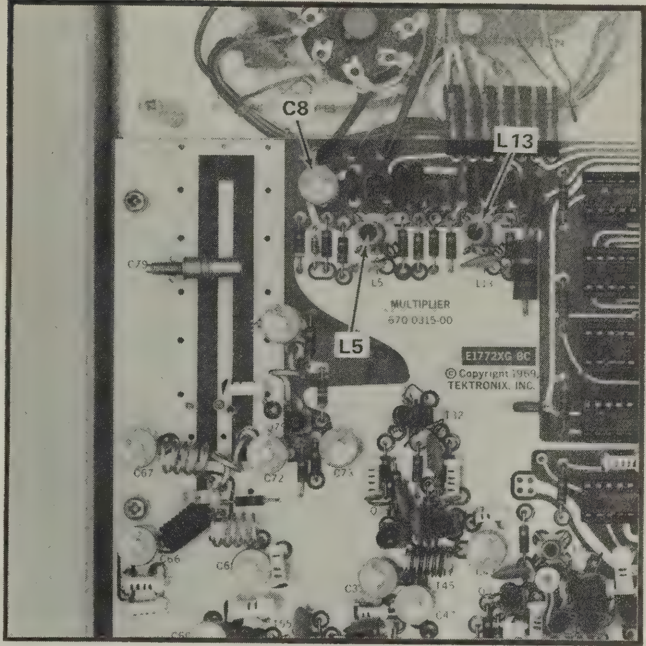


Fig. 5-4. Crystal oscillator frequency and amplitude adjustments.

2) Adjust the vertical deflection of the test oscilloscope, during the tone period, for a dispay amplitude of approximately 4 divisions on the test oscilloscope.

3) Turn the CW or BFO control of the communications receiver on and tune the receiver carefully to the exact frequency of the signal. (When the receiver is properly tuned only the 440 or 1000 Hz tone can be heard.)

4) Turn off the CW or BFO oscillator on the receiver.

5) Install a 50 Ω termination on the MARKER OUTput connector of the 2901 and insert a short (12 or 15 inch) piece of wire into the center conductor of the terminator.

6) Depress the .1 μs MARKER SELECTOR pushbutton on the 2901. The short wire will act as an antenna and radiate the 10 MHz signal from the 2901 so it can be received by the communication receiver. If the signal level is too high, it may block out the NBS signal. If this occurs, shorten the radiating wire.

7) CHECK—The frequency difference or beat frequency between the two signals. Must not exceed 100 Hz (one cycle/division with a Time/cm setting of 10 ms).

8) ADJUST—C8 and L5, as described in Method 1 step e, during the off period of the modulation tone, for minimum beat frequency or minimum signal amplitude on the test oscilloscope. Do not disturb any components in the oscillator circuit after the frequency has been adjusted.

e. Disconnect the radiating wire and termination from the MARKER OUTput connector and apply the .1 μs signal through a coaxial cable and 50 Ω termination to the vertical input of the test oscilloscope. Adjust the test oscilloscope Time/div and Volts/div controls for .1 μs marker display on the oscilloscope.

f. ADJUST—L13 (Fig. 5-4) for maximum marker amplitude. If the core of L13 is moved more than one full turn, readjust L5 to the midpoint of the oscillator operating range. Recheck accuracy of the 10 MHz oscillator.

g. Interaction—Will affect accuracy of all marker and trigger signals when 2901 is operated with internal clock. Will also affect intermodulation distortion of the multiplier outputs.

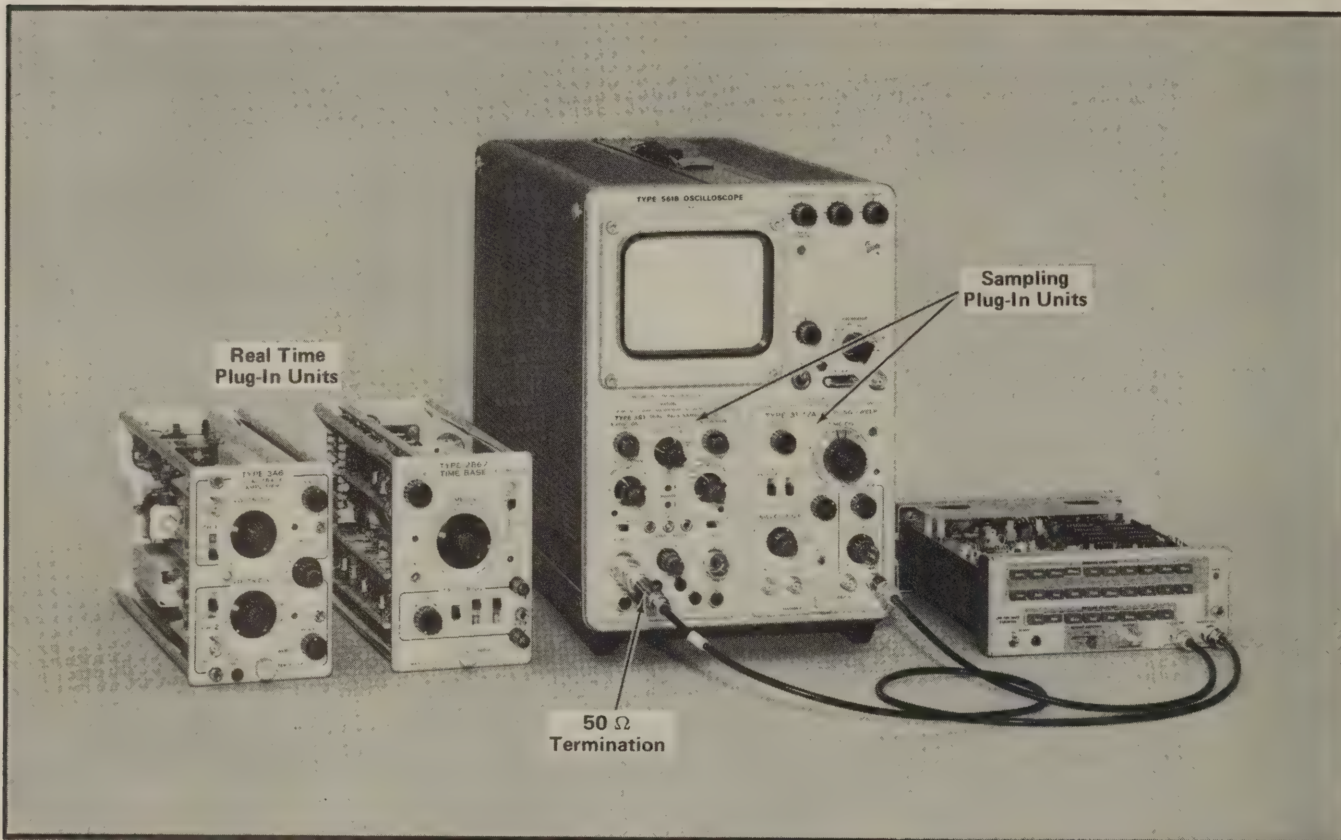


Fig. 5-5. Test equipment setup to check/adjust multiplier output. (50 ns, 10 ns, 5 ns, 2 ns.)

5. Check/Adjust 50 ns Marker Output

a. Test equipment setup is shown in Fig. 5-5.

b. Requirement—50 ns marker period. Amplitude at least 0.5 V peak to peak, into 50 Ω termination.

c. Connect the MARKER OUTput through a 50 Ω coaxial cable to the vertical input of a sampling plug-in unit (Type 3S1 or 1S1). Set the vertical deflection for 200 mV/Div.

d. Apply .1 μs trigger signal from the TRIGGER OUT connector of the 2901 through a 10× attenuator to the external trigger input of the sampling plug-in unit. Adjust the sweep trigger for a triggered display.

e. CHECK—Frequency of the 50 ns marker sine wave and its amplitude. Frequency period 50 ns (20 MHz), amplitude at least 0.5 V peak to peak. (Amplitude two and one half divisions with 200 mV/Div.)

f. ADJUST—50 ns multiplier as follows:

1) Set R25 (Fig. 5-6) midrange.

2) Adjust L28 for maximum amplitude of 50 ns output.

3) Readjust L13 a slight amount for optimum flatness of the 50 ns output and maximum amplitude of the .1 μs marker output.

4) Adjust R24 for optimum flatness of the 50 ns output.

NOTE

These adjustments interact and affect output flatness. Flatness or intermodulation distortion will adversely affect the output of subsequent multipliers. It should not exceed 1% at 20°C in this stage in order to maintain satisfactory flatness through the remaining multipliers. Flatness or intermodulation can be checked as follows:

a) Set the vertical sensitivity of the sampling plug-in unit to 200 mV/Div and adjust the Variable Volts/Div control for a display amplitude of 5 divisions.

b) Increase the deflection sensitivity by a factor of 20 by switching the Volts/Div selector to 10 mV/Div. Each division now represents 1% of the total signal amplitude.

c) Adjust the DC Offset control to position the bottom of the display within the graticule window.

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d) Turn the sampling plug-in unit Time Position control through its range and observe the amplitude difference between the maximum and minimum signal crests, over this range. Should not exceed 1% or 1 division.

e) Adjust the DC Offset control to position the top of the display within the graticule window. Again measure the modulation percentage.

6. Check/Adjust 10 ns Marker Output

a. Test equipment setup is as described for step 5.

b. Requirement—10 ns marker period. Amplitude at least 0.5 V peak to peak into 50 Ω load.

c. Apply 10 ns time markers through a coaxial cable to the input of the sampling vertical plug-in unit.

d. CHECK—Frequency of the 10 ns marker sine wave and amplitude. Frequency period 10 ns (100 MHz). Amplitude at least 0.5 V peak to peak.

e. ADJUST—C39 and C43 (Fig. 5-1) simultaneously for maximum amplitude and flatness of the marker display. Adjust C47 and L50 for maximum amplitude. Check modulation percentage as described in step 5f. Modulation percentage should not exceed 4% at 20°C. (Modulation percentage is a maintenance check and not a specification.)

7. Check/Adjust 5 ns Marker Output

a. Equipment setup is as described for steps 5 and 6.

b. Requirement—5 ns marker period. Amplitude at least 0.5 V peak to peak into 50 Ω load.

c. Apply 5 ns time markers to the input of the sampling vertical plug-in unit.

d. CHECK—Frequency and amplitude of the 5 ns marker. Frequency 200 MHz, amplitude at least 0.5 V peak to peak into 50 Ω.

e. ADJUST—C60 (Fig. 5-6) for maximum amplitude of the 200 MHz (5 ns) sine-wave display. Check intermodulation percentage as described in step 5f. Intermodulation should not exceed 4% at 20°C. (Maintenance check only.) If intermodulation is excessive, adjust L50 a slight amount for optimum flatness.

8. Check/Adjust 2 ns Marker Output

a. Equipment setup is as described for steps 5 through 7.

b. Requirement—2 ns marker period. Amplitude at least 0.3 V peak to peak into 50 Ω load.

c. Apply 2 ns time-markers from the MARKER OUTput connector to the input of a sampling vertical plug-in unit.

d. CHECK—Frequency and amplitude of 2 ns (500 MHz) marker signal. Frequency 500 MHz, amplitude at least 0.3 V peak to peak, into 50 Ω load.

e. ADJUST—C66, C72, and C79 (Fig. 5-6) for maximum signal amplitude. Adjust C67, C69, C73 and C75 for optimum flatness and amplitude. Adjustments C66, C67, C69 and C72 all interact. Do not move these adjustments very far from their original setting. Because of interaction, a number of combinations will produce a 500 MHz output signal. Only one combination, however, provides maximum flatness and amplitude. (It may be necessary to preset the capacitors as shown in Fig. 5-7, to find the optimum combination.)

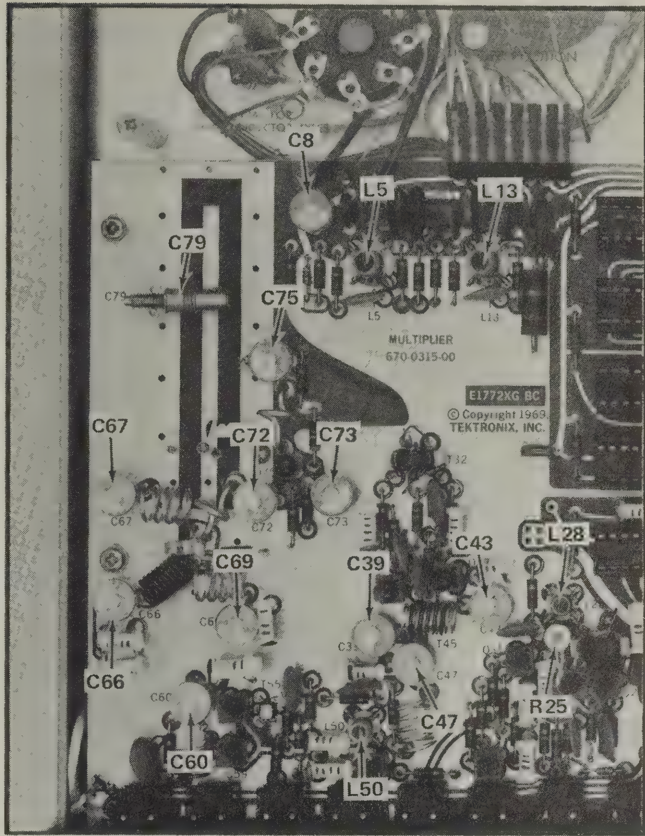


Fig. 5-6. Location of adjustments for multipliers.

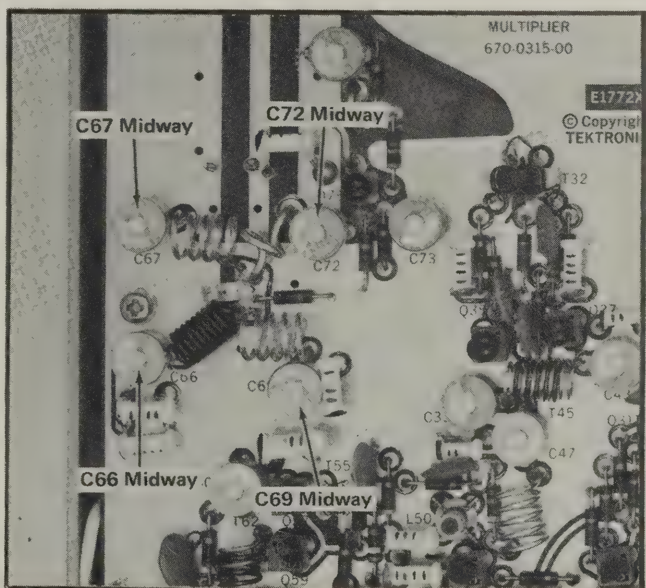


Fig. 5-7. Preset positions for 2 ns (500 MHz) multiplier calibration adjustments.

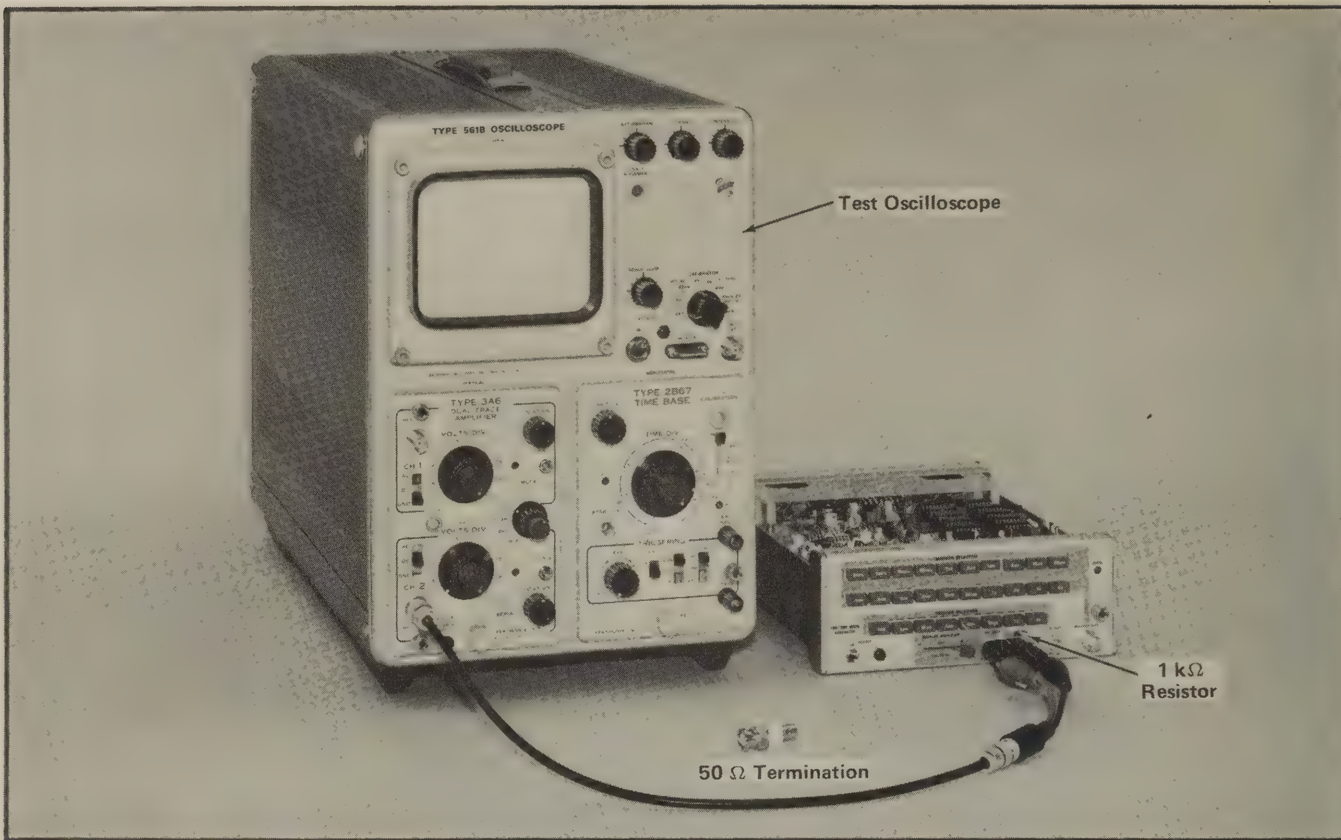


Fig. 5-8. Equipment setup to check— .1 μs to 5 s MARKER OUT amplitude, MARKER AMPLIFIER OUTPUT amplitude, and TRIGGER OUTPUT amplitude.

9. Check Marker Output (.1 μs to 5 s)

a. Equipment setup is shown in Fig. 5-8.

b. Requirement—Marker accuracy depends on crystal oscillator or external clock accuracy. Marker amplitude must equal or exceed 0.5 V peak into 50 Ω load.

c. Connect the TRIGGER OUTput for the 2901 through a coaxial cable to the External Trigger Input of the test oscilloscope time-base unit.

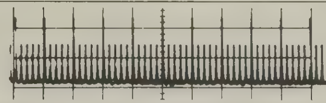
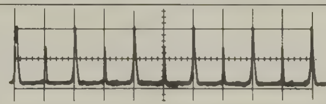
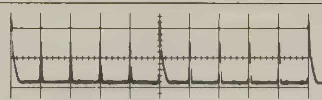
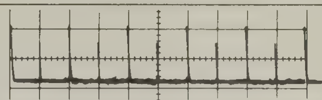
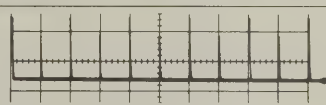
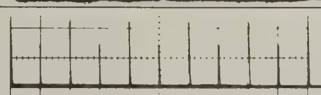
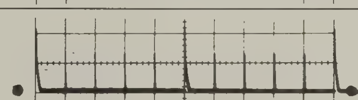
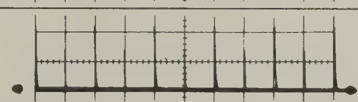
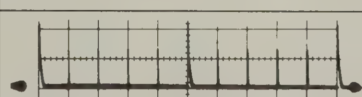
d. Connect the MARKER OUTput through a coaxial cable and 50 Ω termination to a real time oscilloscope vertical plug-in unit. Set the vertical deflection sensitivity to 0.5 Volts/Div and the sweep rate of the time base as per Table 5-1.

e. CHECK—Marker countdown accuracy as per Table 5-1. Markers periods must be displayed at the correct interval through the countdown range of the MARKER SELECTOR.

f. CHECK—Marker amplitude. Repeat each step of Table 5-1, pushing only one MARKER SELECTOR button at a time. Amplitude of markers must equal or exceed 0.5 V peak into 50 Ω load.

NOTES

TABLE 5-1

2901 MARKER SELECTOR	Test Oscilloscope Time/Div	2901 TRIGGER SOURCE	Typical Display
.1 μs and .5 μs	.5 μSEC	1 μs	
.5 μs and 1 μs	.5 μSEC	1 μs	
1 μs and 5 μs	1 μSEC	10 μs	
5 μs and 10 μs	5 μSEC	10 μs	
10 μs and 50 μs	10 μSEC	.1 ms	
50 μs and .1 ms	50 μSEC	.1 ms	
.1 ms and .5 ms	.1 mSEC	1 ms	
.5 ms and 1 ms	.5 mSEC	1 ms	
1 ms and 5 ms	1 mSEC	10 ms	
5 ms and 10 ms	5 mSEC	10 ms	
10 ms and 50 ms	10 mSEC	.1 s	
50 ms and .1 s	50 mSEC	.1 s	
.1 s and .5 s	.1 SEC	1 s	
.5 s and 1 s	.5 SEC	1 s	
1 s and 5 s	1 SEC	1 s	

10. Check Marker Amplifier Output

a. Equipment setup is shown in Fig. 5-8.

b. Requirement—Positive and negative-going markers with amplitude that equals or exceeds 25 V peak into 1 kΩ load.

c. Terminate the OUTPUT of the Marker Amplifier into 1 kΩ load then apply the signal across this termination to the input of the vertical plug-in unit as follows:

Attach a BNC to binding post adapter to the OUTPUT connector. Connect a 1 kΩ, ½ watt resistor across the binding posts of the adapter. Connect a clip lead to BNC adapter across the binding post terminals (red lead to red binding post). Attach a coaxial cable between the BNC to clip lead adapter and the Input of the vertical plug-in unit for the test oscilloscope.

TABLE 5-2

2901 MARKER SELECTOR	Test Oscilloscope Time/Div
1 μs	10 μs
5 μs	10 μs
10 μs	.1 ms
50 μs	.1 ms
.1 ms	1 ms
.5 ms	1 ms
1 ms	10 ms
5 ms	10 ms
10 ms	.1 s
50 ms	.1 s
.1 s	1 s
.5 s	1 s
1 s	1 s
5 s	1 s

d. Set the vertical deflection factor (Volts/Div) to 10. Set the sweep rate (Time/Div) to the settings listed in Table 5-2 and the triggering to Internal.

e. CHECK—The amplitude of the MARKER AMPLIFIER output signal for the marker selections listed in Table 5-2 with the MARKER SELECTOR in the positive (+) then negative (—) positions. Amplitude must equal or exceed 25 V peak, into 1 kΩ load.

11. Check Amplitude of Trigger Output Signal

a. Test equipment setup is shown in Fig. 5-8.

b. Requirement—Positive-going pulses with an amplitude equal to or greater than 0.5 V into 50 Ω.

c. Apply the signal from the TRIGGER OUTput connector through a coaxial cable and 50 Ω termination to the Input of the vertical plug-in unit. Set the vertical sensitivity to 1 Volt/Div.

d. CHECK—Trigger timing and signal amplitude as per Table 5-3. Amplitude must equal or exceed 0.5 V peak.

TABLE 5-3

TRIGGER SELECTOR	Test Oscilloscope Time/Div	Marks/Div
1 μs	1 μs	1
10 μs	10 μs	1
.1 ms	.1 ms	1
1 ms	1 ms	1
10 ms	10 ms	1
.1 s	.1 s	1
1 s	1 s	1

NOTES

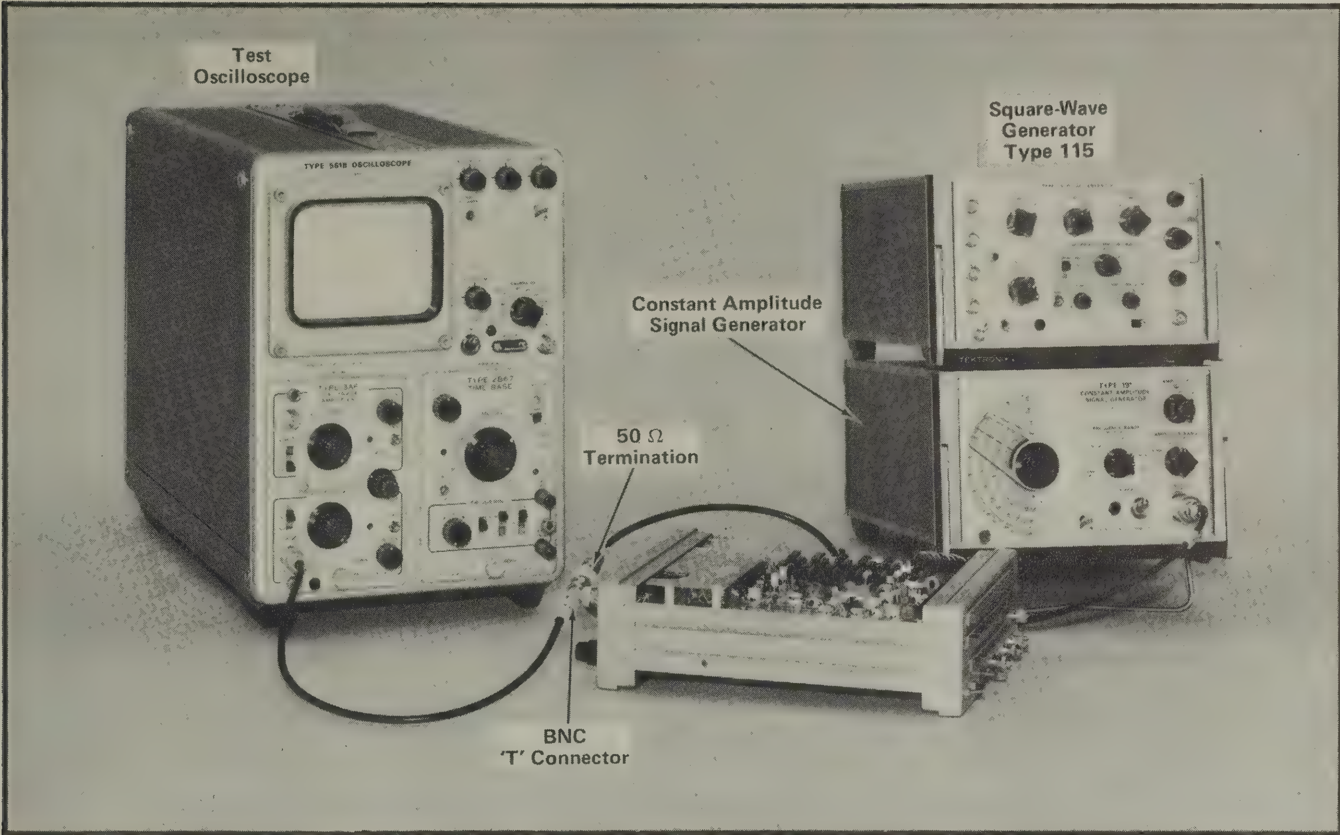


Fig. 5-9. Equipment setup to check 2901 countdown operation with an external clock signal applied.

12. Check External Clock Input Operation

a. Test equipment setup is shown in Fig. 5-9.

b. Requirement—An input clock signal with an amplitude of 2 V or more peak to peak or 2 V peak, to a maximum amplitude of 5 V (DC + peak AC) will gate the frequency countdown circuits. Reset level is +50 mV or less. Frequency range is 50 kHz or less to at least 10 MHz. Frequencies below 50 kHz are usable, provided the risetime of the clock pulse equals or exceeds 1 V/μs.

c. Apply the output of a constant amplitude signal generator through a 50 Ω termination, a BNC 'T' connector and a coaxial cable to the EXT CLOCK INPUT connector (on the back panel) of the 2901. Switch the CLOCK switch to EXT position.

d. Connect the Input for Channel 1 of the test oscilloscope vertical plug-in unit to the open end of the BNC 'T' connector. This will allow the signal amplitude from the signal generator to be monitored by the test oscilloscope.

e. Set the signal generator frequency to 10 MHz. Adjust the generator output for a signal amplitude of 2 V peak to peak on the test oscilloscope. Switch the CLOCK selector for the 2901 to EXT position. Depress the .1 μs MARKER SELECTOR button.

f. Apply the MARKER OUTput signal through a coaxial cable and 50 Ω termination to the second channel of the vertical amplifier plug-in unit. Switch the vertical unit Mode selector to this channel then adjust the vertical sensitivity, time base sweep rate (Time/Div), and triggering for a triggered display.

g. CHECK—That the marker output frequency follows the input clock frequency as the signal generator frequency is decreased down to 350 kHz.

h. Return the external clock frequency to 10 MHz and depress the 1 ms MARKER SELECTOR pushbutton.

i. Adjust the test oscilloscope Time/Div and triggering for a satisfactory display.

j. CHECK—That the countdown circuits follow the input clock frequency as the signal generator frequency is varied between 10 MHz and 350 kHz. (Input clock signal amplitude must equal or exceed 2 V peak to peak but must not exceed 5 V (DC + peak AC).

k. Remove the signal from the constant amplitude signal generator and apply the positive-going pulse from a pulse generator, through a 50 Ω coaxial cable and 50 Ω termination to the EXT CLOCK INPUT connector.

l. Set the pulse period to 5 μs, the pulse duration to 2 μs, pulse amplitude for 2 volt peak and risetime for 1 V/μs.

m. CHECK—That the countdown circuits follow the input pulse repetition rate as the pulse generator period is increased from 5 μs. (PRF decreases below 250 kHz.) Pulse risetime must equal or exceed 1 V/μs.

This completes the performance or calibration check of the 2901. If the instrument has equalled or exceeded all checks it will operate within the characteristics listed in the Specification section.

NOTES

PARTS LIST ABBREVIATIONS

BHB	binding head brass	int	internal
BHS	binding head steel	lg	length or long
cap.	capacitor	met.	metal
cer	ceramic	mtg hdw	mounting hardware
comp	composition	OD	outside diameter
conn	connector	OHB	oval head brass
CRT	cathode-ray tube	OHS	oval head steel
csk	countersunk	PHB	pan head brass
DE	double end	PHS	pan head steel
dia	diameter	plstc	plastic
div	division	PMC	paper, metal cased
elect.	electrolytic	poly	polystyrene
EMC	electrolytic, metal cased	prec	precision
EMT	electrolytic, metal tubular	PT	paper, tubular
ext	external	PTM	paper or plastic, tubular, molded
F & I	focus and intensity	RHB	round head brass
FHB	flat head brass	RHS	round head steel
FHS	flat head steel	SE	single end
Fil HB	fillister head brass	SN or S/N	serial number
Fil HS	fillister head steel	SW	switch
h	height or high	TC	temperature compensated
hex.	hexagonal	THB	truss head brass
HHB	hex head brass	thk	thick
HHS	hex head steel	THS	truss head steel
HSB	hex socket brass	tub.	tubular
HSS	hex socket steel	var	variable
ID	inside diameter	w	wide or width
incd	incandescent	WW	wire-wound

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

SPECIAL NOTES AND SYMBOLS

×000	Part first added at this serial number
00×	Part removed after this serial number
*000-0000-00	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components.
Use 000-0000-00	Part number indicated is direct replacement.
	Screwdriver adjustment.
	Control, adjustment or connector.

INDEX OF ELECTRICAL PARTS LIST

SECTION 6
ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			

CHASSIS

Bulbs

DS405	150-0035-00			Neon, AID T2			
DS424	150-0045-00			Incandescent #685			

Capacitors

Tolerance ±20% unless otherwise indicated.

C348	290-0267-00			1 μF	Elect.	35 V	
C349	281-0523-00			100 pF	Cer	350 V	
C406	283-0044-00			0.001 μF	Cer	3000 V	
C407	283-0044-00			0.001 μF	Cer	3000 V	
C430	290-0278-00			550 pF	Elect.	50 V	

Semiconductor Device, Diode

CR348	152-0333-00			Silicon	High speed and conductance		

Fuse

F401	159-0029-00			0.3 A	3 AG	Fast-Blo	

Connectors

J19	131-0955-00			Receptacle, electrical, BNC			
J320	131-0955-00			Receptacle, electrical, BNC			
J349	131-0955-00			Receptacle, electrical, BNC			
J369	131-0955-00			Receptacle, electrical, BNC			

Transistor

Q424	151-0258-00			Silicon	PNP	TO-3	2N4905

CHASSIS (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description		
R349	315-0101-00			100 Ω	¼ W	5%
R406	315-0105-00			1 MΩ	¼ W	5%
R407	315-0105-00			1MΩ	¼ W	5%
R409	315-0104-00			100 kΩ	¼ W	5%

Switches

Wired or Unwired

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
S19	2′0-0447-00			Slide	CLOCK
S340	260-0726-00			Lever	MARKER AMPLIFIER
S401	260-0613-00			Toggle	POWER ON
S403	260-0747-00			Slide	LINE VOLTAGE

Transformer

Ckt. No.	Tektronix Part No.	Eff	Disc	Description
T403	*120-0645-00			Power

Crystal

Ckt. No.	Tektronix Part No.	Eff	Disc	Description
Y8	158-0023-01			10 MC, assembly

DIVIDER Circuit Board Assembly

*670-0314-00 Complete Board

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
C202	283-0051-00			0.0033 μF	Cer	100 V	5%
C212	283-0003-00			0.01 μF	Cer	150 V	
C222	283-0092-00			0.03 μF	Cer	200 V	+80%—20%
C232	283-0081-00			0.1 μF	Cer	25 V	+80%—20%
C242	290-0288-00			0.27 μF	Elect.	35 V	10%
C252	290-0245-00			1.5 μF	Elect.	10 V	10%
C262	290-0246-00			3.3 μF	Elect.	15 V	10%
C272	290-0135-00			15 μF	Elect.	20 V	
C282	290-0297-00			39 μF	Elect.	10 V	10%
C292	290-0248-01			150 μF	Elect.	15 V	

DIVIDER Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				Capacitors (cont)		
C321	283-0178-00			0.1 μF	Cer 100 V	+80%—20%
C323	281-0628-00			15 pF	Cer 600 V	5%
C332	283-0178-00			0.1 μF	Cer 100 V	+80%—20%
C338	281-0511-00			22 pF	Cer 500 V	10%
C347	283-0003-00			0.01 μF	Cer 150 V	
C366	283-0177-00			1 μF	Cer 25 V	+80%—20%
C411	290-0440-00			5200 μF	Elect. 10 V	+75%—10%
C426	290-0134-00			22 μF	Elect. 15 V	+20%—0%
C453	290-0175-00			10 μF	Elect. 35 V	
				Semiconductor Device, Diodes		
CR325	152-0141-02			Silicon	1N4152	
CR329	152-0333-00			Silicon	High speed and conductance	
CR411A, B, C, D	152-0199-00			Rectifier bridge	MDA962-3	
CR430A, B, C, D	*152-0107-00			Silicon	Replaceable by 1N647	
CR432	152-0141-02			Silicon	1N4152	
VR432	152-0149-00			Zener	1N961B 0.4 W, 10 V, 5%	
CR436	152-0141-02			Silicon	1N4152	
				Inductor		
L321	*108-0300-00			0.2 μH		
				Transistors		
Q204	151-0190-00			Silicon	NPN	TO-92 2N3904
Q214	151-0190-00			Silicon	NPN	TO-92 2N3904
Q224	151-0190-00			Silicon	NPN	TO-92 2N3904
Q234	151-0190-00			Silicon	NPN	TO-92 2N3904
Q244	151-0190-00			Silicon	NPN	TO-92 2N3904
Q254	151-0190-00			Silicon	NPN	TO-92 2N3904
Q264	151-0190-00			Silicon	NPN	TO-92 2N3904
Q274	151-0190-00			Silicon	NPN	TO-92 2N3904
Q284	151-0190-00			Silicon	NPN	TO-92 2N3904
Q294	151-0190-00			Silicon	NPN	TO-92 2N3904
Q330	151-0190-00			Silicon	NPN	TO-92 2N3904
Q340	151-0188-00			Silicon	PNP	TO-92 2N3906
Q345	151-0190-00			Silicon	NPN	TO-92 2N3904
Q347	151-0188-00			Silicon	PNP	TO-92 2N3906
Q366	151-0190-00			Silicon	NPN	TO-92 2N3904

DIVIDER Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Transistors *(cont)*			
Q413	151-0190-00			Silicon	NPN	TO-92	2N3904
Q417	151-0190-00			Silicon	NPN	TO-92	2N3904
Q422	151-0164-00			Silicon	PNP	TO-5	2N3702
Q436	151-0190-00			Silicon	NPN	TO-92	2N3904
Q439	151-0190-00			Silicon	NPN	TO-92	2N3904
Q458	151-0208-00			Silicon	PNP	TO-5	2N4036

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Value	Power	Tolerance
R202	315-0123-00			12 kΩ	¼ W	5%
R203	315-0222-00			2.2 kΩ	¼ W	5%
R205	315-0221-00			220 Ω	¼ W	5%
R212	315-0123-00			12 kΩ	¼ W	5%
R213	315-0222-00			2.2 kΩ	¼ W	5%
R215	315-0221-00			220 Ω	¼ W	5%
R222	315-0123-00			12 kΩ	¼ W	5%
R223	315-0222-00			2.2 kΩ	¼ W	5%
R225	315-0221-00			220 Ω	¼ W	5%
R232	315-0123-00			12 kΩ	¼ W	5%
R233	315-0222-00			2.2 kΩ	¼ W	5%
R235	315-0221-00			220 Ω	¼ W	5%
R242	315-0123-00			12 kΩ	¼ W	5%
R243	315-0222-00			2.2 kΩ	¼ W	5%
R245	315-0221-00			220 Ω	¼ W	5%
R252	315-0123-00			12 kΩ	¼ W	5%
R253	315-0222-00			2.2 kΩ	¼ W	5%
R255	315-0221-00			220 Ω	¼ W	5%
R262	315-0123-00			12 kΩ	¼ W	5%
R263	315-0222-00			2.2 kΩ	¼ W	5%
R265	315-0221-00			220 Ω	¼ W	5%
R272	315-0123-00			12 kΩ	¼ W	5%
R273	315-0222-00			2.2 kΩ	¼ W	5%
R275	315-0221-00			220 Ω	¼ W	5%
R282	315-0123-00			12 kΩ	¼ W	5%
R283	315-0222-00			2.2 kΩ	¼ W	5%
R285	315-0221-00			220 Ω	¼ W	5%
R292	315-0123-00			12 kΩ	¼ W	5%
R293	315-0222-00			2.2 kΩ	¼ W	5%
R295	315-0221-00			220 Ω	¼ W	5%
R323	315-0221-00			220 Ω	¼ W	5%
R325	315-0473-00			47 kΩ	¼ W	5%
R327	315-0511-00			510 Ω	¼ W	5%
R328	315-0222-00			2.2 kΩ	¼ W	5%
R330	315-0272-00			2.7 kΩ	¼ W	5%

DIVIDER Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Resistors (cont)			
R337	315-0273-00			27 kΩ	1/4 W		5%
R338	315-0222-00			2.2 kΩ	1/4 W		5%
R342	315-0272-00			2.7 kΩ	1/4 W		5%
R347	315-0101-00			100 Ω	1/4 W		5%
R362	315-0221-00			220 Ω	1/4 W		5%
R364	315-0102-00			100 Ω	1/4 W		5%
R366	315-0220-00			22 Ω	1/4 W		5%
R368	315-0221-00			220 Ω	1/4 W	WW	
R411	308-0499-00			0.5 Ω	2 1/2 W		5%
R413	315-0103-00			10 kΩ	1/4 W		5%
R415	315-0103-00			10 kΩ	1/4 W		5%
R418	315-0102-00			100 Ω	1/4 W		5%
R419	315-0153-00			15 kΩ	1/4 W		5%
R421	321-0216-00			1.74 kΩ	1/8 W	Prec	1%
R424	315-0680-00			68 Ω	1/4 W		5%
R430	315-0100-00			10 Ω	1/4 W		5%
R434	315-0103-00			10 kΩ	1/4 W		5%
R436	315-0222-00			2.2 kΩ	1/4 W		5%
R438	315-0103-00			10 kΩ	1/4 W		5%
R450	315-0202-00			2 kΩ	1/4 W		5%
R451	311-0704-00			500 Ω, Var			
R452	315-0392-00			3.9 kΩ	1/4 W		5%
R455	315-0153-00			15 kΩ	1/4 W		5%
R457	315-0224-00			220 kΩ	1/4 W		5%
				Switches			
	Wired or Unwired						
S300B	260-1110-00			Pushbutton	MARKER SELECTOR (lower)		
S360	260-1109-00			Pushbutton	TRIGGER SELECTOR		
				Integrated Circuits			
U200	156-0044-00			Dual J-K Flip-flop	Replaceable by Motorola MC890P		
U202	156-0021-00			Hex inv	Replaceable by Motorola MC889P		
U210	156-0059-00			Dual J-K Flip-flop	Replaceable by Motorola MC891P		
U212	156-0021-00			Hex inv	Replaceable by Motorola MC889P		
U220	156-0044-00			Dual J-K Flip-flop	Replaceable by Motorola MC890P		
U230	156-0059-00			Dual J-K Flip-flop	Replaceable by Motorola MC891P		
U240	156-0044-00			Dual J-K Flip-flop	Replaceable by Motorola MC890P		
U250	156-0059-00			Dual J-K Flip-flop	Replaceable by Motorola MC891P		
U260	156-0044-00			Dual J-K Flip-flop	Replaceable by Motorola MC890P		
U270	156-0059-00			Dual J-K Flip-flop	Replaceable by Motorola MC891P		

DIVIDER Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			

Integrated Circuits (cont)

U280	156-0044-00			Dual J-K Flip-flop	Replaceable by Motorola MC890P
U290	156-0044-00			Dual J-K Flip-flop	Replaceable by Motorola MC890P

MULTIPLIER Circuit Board Assembly

	*670-0315-00	Complete Board

Capacitors

Tolerance ±20% unless otherwise indicated.

C1	283-0067-00		0.001 μF	Cer	200 V	10%
C4	283-0003-00		0.01 μF	Cer	150 V	
C6	283-0644-00		150 pF	Mica	500 V	1%
C8	281-0092-00		9-35 pF, Var	Cer		
C10	283-0620-00		470 pF	Mica	300 V	1%
C13	283-0003-00		0.01 μF	Cer	150 V	
C14	283-0644-00		150 pF	Mica	500 V	1%
C16	283-0003-00		0.01 μF	Cer	150 V	
C17	283-0620-00		470 pF	Mica	300 V	1%
C19	283-0178-00		0.1 μF	Cer	100 V	+80%—20%
C21	283-0546-00		330 pF	Cer	500 V	10%
C23	283-0003-00		0.01 μF	Cer	150 V	
C25	281-0536-00		1000 pF	Cer	500 V	10%
C26	283-0003-00		0.01 μF	Cer	150 V	
C28	283-0003-00		0.01 μF	Cer	150 V	
C29	281-0546-00		330 pF	Cer	500 V	10%
C30	281-0536-00		1000 pF	Cer	500 V	10%
C33	283-0003-00		0.01 μF	Cer	150 V	
C35	281-0523-00		100 pF	Cer	350 V	
C37	281-0523-00		100 pF	Cer	350 V	
C39	281-0093-00		5.5-18 pF, Var	Cer		
C41	283-0003-00		0.01 μF	Cer	150 V	
C43	281-0093-00		5.5 -18 pF, Var	Cer		
C44	281-0613-00		10 pF	Cer	200 V	10%
C45	283-0003-00		0.01 μF	Cer	150 V	
C46	281-0613-00		10 pF	Cer	200 V	10%
C47	281-0091-00		2-8 pF, Var	Cer		
C50	283-0003-00		0.01 μF	Cer	150 V	
C51	281-0513-00		27 pF	Cer	500 V	
C52	281-0549-00		68 pF	Cer	500 V	10%

MULTIPLIER Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Capacitors (cont)			
C56	283-0003-00			0.01 μF	Cer	150 V	
C60	281-0091-00			2-8 pF, Var	Cer		
C61	281-0629-00			33 pF	Cer	600 V	5%
C62	283-0003-00			0.01 μF	Cer	150 V	
C64	281-0628-00			15 pF	Cer	600 V	5%
C65	281-0523-00			100 pF	Cer	350 V	
C66	281-0091-00			2-8 pF, Var	Cer		
C67	281-0091-00			2-8 pF, Var	Cer		
C68	281-0500-00			2.2 pF	Cer	500 V	±0.5 pF
C69	281-0091-00			2-8 pF, Var	Cer		
C72	281-0091-00			2-8 pF, Var	Cer		
C73	281-0092-00			9-35 pF, Var	Cer		
C75	281-0092-00			9-35 pF, Var	Cer		
C76	281-0529-00			1.5 pF	Cer	500 V	±0.25 p
C79	281-0027-00			0.7-3 pF, Var	Tub.		
C90	283-0177-00			1 μF	Cer	25 V	+80%—20%
C111	281-0629-00			33 pF	Cer	600 V	5%
C130	281-0524-00			150 pF	Cer	500 V	
C135	281-0518-00			47 pF	Cer	500 V	
C143	283-0178-00			0.1 μF	Cer	100 V	+80%—20%
C154	281-0523-00			100 pF	Cer	350 V	
C165	281-0524-00			150 pF	Cer	500 V	
C175	281-0546-00			330 pF	Cer	500 V	10%
C185	283-0114-00			0.0015 μF	Cer	200 V	5%
C409	283-0044-00			0.001 μF	Cer	3000 V	
				Semiconductor Device, Diodes			
CR1	152-0141-02			Silicon	1N4152		
CR71	152-0230-00			Variable capacity 6.8 pF			
CR334	152-0141-02			Silicon	1N4152		
				Inductors			
L5	*114-0220-00			1-3 μH, Var	Core 276-0568-00		
L13	*114-0220-00			1-3 μH, Var	Core 276-0568-00		
L28	*114-0295-00			0.3-0.55 μH, Var	Core 276-0582-00		
L47	*108-0347-00			0.12 μH			
L50	*114-0294-00			98-150 nH	Core 276-0582-00		
L66	*108-0300-00			0.2 μH			
L67	*108-0347-00			0.12 μH			
L69	*108-0347-00			0.12 μH			
L72	*108-0301-00			0.025 μH			
L75	*108-0301-00			0.025 μH			
L79[1]							

[1]**Part of Multiplier Circuit Board.**

MULTIPLIER Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				Transistors		
Q5	151-0225-00			Silicon	NPN TO-18 2N3563	
Q13	*151-0198-00			Silicon	NPN TO-92 Replaceable by MPS 918	
Q25	*151-0198-00			Silicon	NPN TO-92 Replaceable by MPS 918	
Q27	*151-0198-00			Silicon	NPN TO-92 Replaceable by MPS 918	
Q35	*151-0269-00			Silicon	NPN TO-106 Selected from SE 3005	
Q37	*151-0269-00			Silicon	NPN TO-106 Selected from SE 3005	
Q50	*151-0198-00			Silicon	NPN TO-92 Replaceable by MPS 918	
Q57	*151-0198-00			Silicon	NPN TO-92 Replaceable by MPS 918	
Q59	*151-0198-00			Silicon	NPN TO-92 Replaceable by MPS 918	
Q75	*151-0269-00			Silicon	NPN TO-106 Selected from SE 3005	
Q106	151-0190-00			Silicon	NPN TO-92 2N3904	
Q116	151-0190-00			Silicon	NPN TO-92 2N3904	
Q138	151-0190-00			Silicon	NPN TO-92 2N3904	
Q145	151-0190-00			Silicon	NPN TO-92 2N3904	
Q158	151-0190-00			Silicon	NPN TO-92 2N3904	
Q168	151-0190-00			Silicon	NPN TO-92 2N3904	
Q178	151-0190-00			Silicon	NPN TO-92 2N3904	
Q188	151-0190-00			Silicon	NPN TO-92 2N3904	
Q312	151-0190-00			Silicon	NPN TO-92 2N3904	
Q317	151-0188-00			Silicon	PNP TO-92 2N3906	
				Resistors		
Resistors are fixed, composition, ±10% unless otherwise indicated.						
R1	315-0222-00			2.2 kΩ	¼ W	5%
R3	315-0682-00			6.8 kΩ	¼ W	5%
R4	315-0511-00			510 Ω	¼ W	5%
R8	315-0471-00			470 Ω	¼ W	5%
R10	315-0221-00			220 Ω	¼ W	5%
R11	315-0102-00			1 kΩ	¼ W	5%
R13	315-0220-00			22 Ω	¼ W	5%
R16	315-0270-00			27 Ω	¼ W	5%
R19	303-0510-00			51 Ω	1 W	5%
R21	315-0100-00			10 Ω	¼ W	5%
R22	315-0272-00			2.7 kΩ	¼ W	5%
R23	315-0471-00			470 Ω	¼ W	5%
R25	311-0643-00			50 Ω, Var		5%
R26	315-0220-00			22 Ω	¼ W	5%
R28	315-0100-00			10 Ω	¼ W	5%
R32	315-0362-00			3.6 kΩ	¼ W	5%
R33	315-0101-00			100 Ω	¼ W	5%
R35	315-0100-00			10 Ω	¼ W	5%
R37	315-0100-00			10 Ω	¼ W	5%
R41	315-0220-00			22 Ω	¼ W	5%

MULTIPLIER Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				Resistors (cont)		
R45	315-0100-00			10 Ω	¼ W	5%
R48	315-0473-00			47 kΩ	¼ W	5%
R50	315-0220-00			22 Ω	¼ W	5%
R53	315-0100-00			10 Ω	¼ W	5%
R54	317-0510-00			51 Ω	⅛ W	5%
R55	315-0472-00			4.7 kΩ	¼ W	5%
R56	315-0391-00			390 Ω	¼ W	5%
R58	315-0220-00			22 Ω	¼ W	5%
R62	315-0100-00			10 Ω	¼ W	5%
R70	315-0105-00			1 MΩ	¼ W	5%
R73	315-0303-00			30 kΩ	¼ W	5%
R74	317-0100-00			10 Ω	⅛ W	5%
R75	315-0510-00			51 Ω	¼ W	5%
R77	315-0150-00			15 Ω	¼ W	5%
R101	315-0332-00			3.3 kΩ	¼ W	5%
R102	315-0102-00			1 kΩ	¼ W	5%
R105	315-0122-00			1.2 kΩ	¼ W	5%
R108	315-0151-00			150 Ω	¼ W	5%
R111	315-0681-00			680 Ω	¼ W	5%
R113	315-0102-00			1 kΩ	¼ W	5%
R114	315-0122-00			1.2 kΩ	¼ W	5%
R117	315-0102-00			1 kΩ	¼ W	5%
R119	315-0151-00			150 Ω	¼ W	5%
R133	315-0681-00			680 Ω	¼ W	5%
R136	315-0152-00			1.5 kΩ	¼ W	5%
R137	315-0102-00			1 kΩ	¼ W	5%
R139	315-0181-00			180 Ω	¼ W	5%
R143	315-0272-00			2.7 kΩ	¼ W	5%
R144	315-0182-00			1.8 kΩ	¼ W	5%
R148	315-0151-00			150 Ω	¼ W	5%
R153	315-0681-00			680 Ω	¼ W	5%
R155	315-0272-00			2.7 kΩ	¼ W	5%
R156	315-0102-00			1 kΩ	¼ W	5%
R159	315-0181-00			180 Ω	¼ W	5%
R165	315-0123-00			12 kΩ	¼ W	5%
R166	315-0222-00			2.2 kΩ	¼ W	5%
R169	315-0181-00			180 Ω	¼ W	5%
R175	315-0123-00			12 kΩ	¼ W	5%
R176	315-0222-00			2.2 kΩ	¼ W	5%
R179	315-0221-00			220 Ω	¼ W	5%

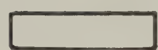
MULTIPLIER Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				Resistors (cont)		
R185	315-0123-00			12 kΩ	¼ W	5%
R186	315-0222-00			2.2 kΩ	¼ W	5%
R189	315-0221-00			220 Ω	¼ W	5%
R310	315-0511-00			510 Ω	¼ W	5%
R312	315-0202-00			2 kΩ	¼ W	5%
R314	315-0221-00			220 Ω	¼ W	5%
R316	315-0151-00			150 Ω	¼ W	5%
R319	315-0220-00			22 Ω	¼ W	
R334	315-0123-00			12 kΩ	¼ W	
R335	315-0123-00			12 kΩ	¼ W	
				Switch		
S300A	260-1111-00			Pushbutton	MARKER SELECTOR (upper)	
				Transformers		
T22	*120-0194-01			Toroid, 4 turns, trifilar		
T32	*120-0194-01			Toroid, 4 turns, trifilar		
T45	*120-0646-00			High frequency, 100 MHz		
T55	*120-0310-00			Toroid, 3 turns, trifilar		
T62A	*108-0571-00			62 nH		
T62B	*108-0572-00			42 nH		
				Integrated Circuits		
U101	156-0021-00			Hex inv	Replaceable by Motorola MC889P	
U110	156-0021-00			Hex inv	Replaceable by Motorola MC889P	
U120	*156-0044-01			Dual J-K Flip-flop	Replaceable by Motorola MC890P, checked	
U125	156-0020-00			Quad 2 input gate	Replaceable by Motorola MC824P	
U130	156-0021-00			Hex inv	Replaceable by Motorola MC889P	
U140	*156-0044-01			Dual J-K Flip-flop	Replaceable by Motorola MC890P, checked	
U160	156-0044-00			Dual J-K Flip-flop	Replaceable by Motorola MC890P	
U165	156-0044-00			Dual J-K Flip-flop	Replaceable by Motorola MC890P	
U180	156-0044-00			Dual J-K Flip-flop	Replaceable by Motorola MC890P	
U185	156-0044-00			Dual J-K Flip-flop	Replaceable by Motorola MC890P	

SECTION 7
DIAGRAMS
AND
MECHANICAL PARTS ILLUSTRATIONS

The following special symbols are used on the diagrams:


Screwdriver adjustment


Front or rear-panel control or connector.

Refers to the indicated diagram.


Connection soldered to circuit board.

Blue line encloses components located on circuit board.

TIME MARK GENERATOR 2901
WAVEFORM CONDITIONS

Waveforms shown on the diagrams are actual waveform photographs taken with a Tektronix Trace Recording Camera equipped with a projected graticule. Voltages and waveforms on the schematic (shown in blue) are not absolute and can vary between instruments. Differences between voltage levels measured and those shown on the waveforms may be due to circuit loading of the measuring device.

The waveforms were obtained using a sampling system (Type 545B with 1S1) for the multiplier schematic and a real time system with storage (Type 549 with 1A1) for the divider circuits.

The MARKER OUTPUT connector was terminated into 50 Ω load. The Volts/Div and Time/Div settings of the test oscilloscope are noted on each waveform.

MULTIPLIER Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				Resistors (cont)		
R185	315-0123-00			12 kΩ	¼ W	5%
R186	315-0222-00			2.2 kΩ	¼ W	5%
R189	315-0221-00			220 Ω	¼ W	5%
R310	315-0511-00			510 Ω	¼ W	5%
R312	315-0202-00			2 kΩ	¼ W	5%
R314	315-0221-00			220 Ω	¼ W	5%
R316	315-0151-00			150 Ω	¼ W	5%
R319	315-0220-00			22 Ω	¼ W	
R334	315-0123-00			12 kΩ	¼ W	
R335	315-0123-00			12 kΩ	¼ W	
				Switch		
S300A	260-1111-00			Pushbutton	MARKER SELECTOR (upper)	
				Transformers		
T22	*120-0194-01			Toroid, 4 turns, trifilar		
T32	*120-0194-01			Toroid, 4 turns, trifilar		
T45	*120-0646-00			High frequency, 100 MHz		
T55	*120-0310-00			Toroid, 3 turns, trifilar		
T62A	*108-0571-00			62 nH		
T62B	*108-0572-00			42 nH		
				Integrated Circuits		
U101	156-0021-00			Hex inv	Replaceable by Motorola MC889P	
U110	156-0021-00			Hex inv	Replaceable by Motorola MC889P	
U120	*156-0044-01			Dual J-K Flip-flop	Replaceable by Motorola MC890P, checked	
U125	156-0020-00			Quad 2 input gate	Replaceable by Motorola MC824P	
U130	156-0021-00			Hex inv	Replaceable by Motorola MC889P	
U140	*156-0044-01			Dual J-K Flip-flop	Replaceable by Motorola MC890P, checked	
U160	156-0044-00			Dual J-K Flip-flop	Replaceable by Motorola MC890P	
U165	156-0044-00			Dual J-K Flip-flop	Replaceable by Motorola MC890P	
U180	156-0044-00			Dual J-K Flip-flop	Replaceable by Motorola MC890P	
U185	156-0044-00			Dual J-K Flip-flop	Replaceable by Motorola MC890P	

SECTION 7
DIAGRAMS
AND
MECHANICAL PARTS ILLUSTRATIONS

The following special symbols are used on the diagrams:

Screwdriver adjustment

Front or rear-panel control or connector.

3 Refers to the indicated diagram.

Connection soldered to circuit board.

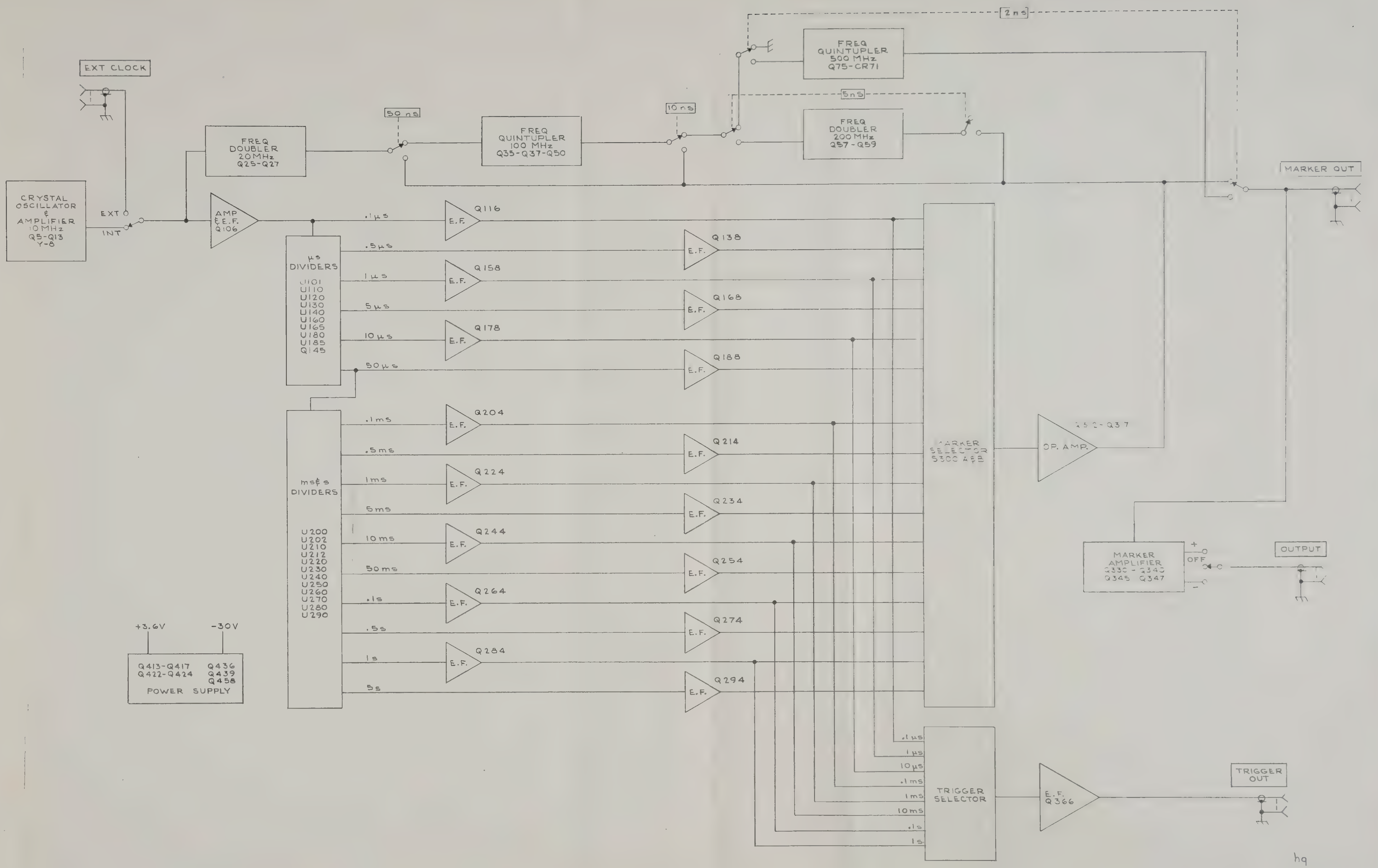
Blue line encloses components located on circuit board.

TIME MARK GENERATOR 2901
WAVEFORM CONDITIONS

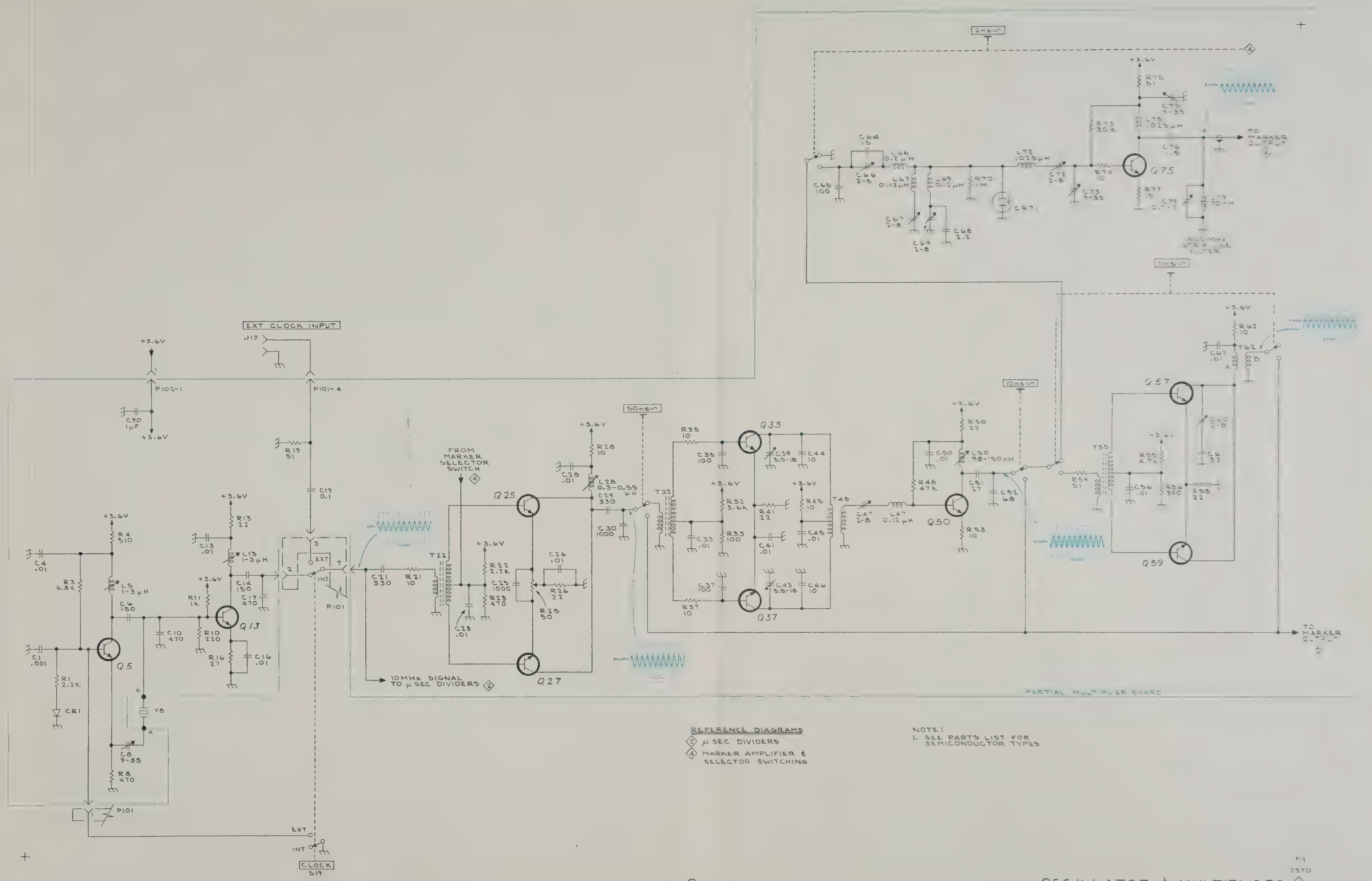
Waveforms shown on the diagrams are actual waveform photographs taken with a Tektronix Trace Recording Camera equipped with a projected graticule. Voltages and waveforms on the schematic (shown in blue) are not absolute and can vary between instruments. Differences between voltage levels measured and those shown on the waveforms may be due to circuit loading of the measuring device.

The waveforms were obtained using a sampling system (Type 545B with 1S1) for the multiplier schematic and a real time system with storage (Type 549 with 1A1) for the divider circuits.

The MARKER OUTPUT connector was terminated into 50 Ω load. The Volts/Div and Time/Div settings of the test oscilloscope are noted on each waveform.



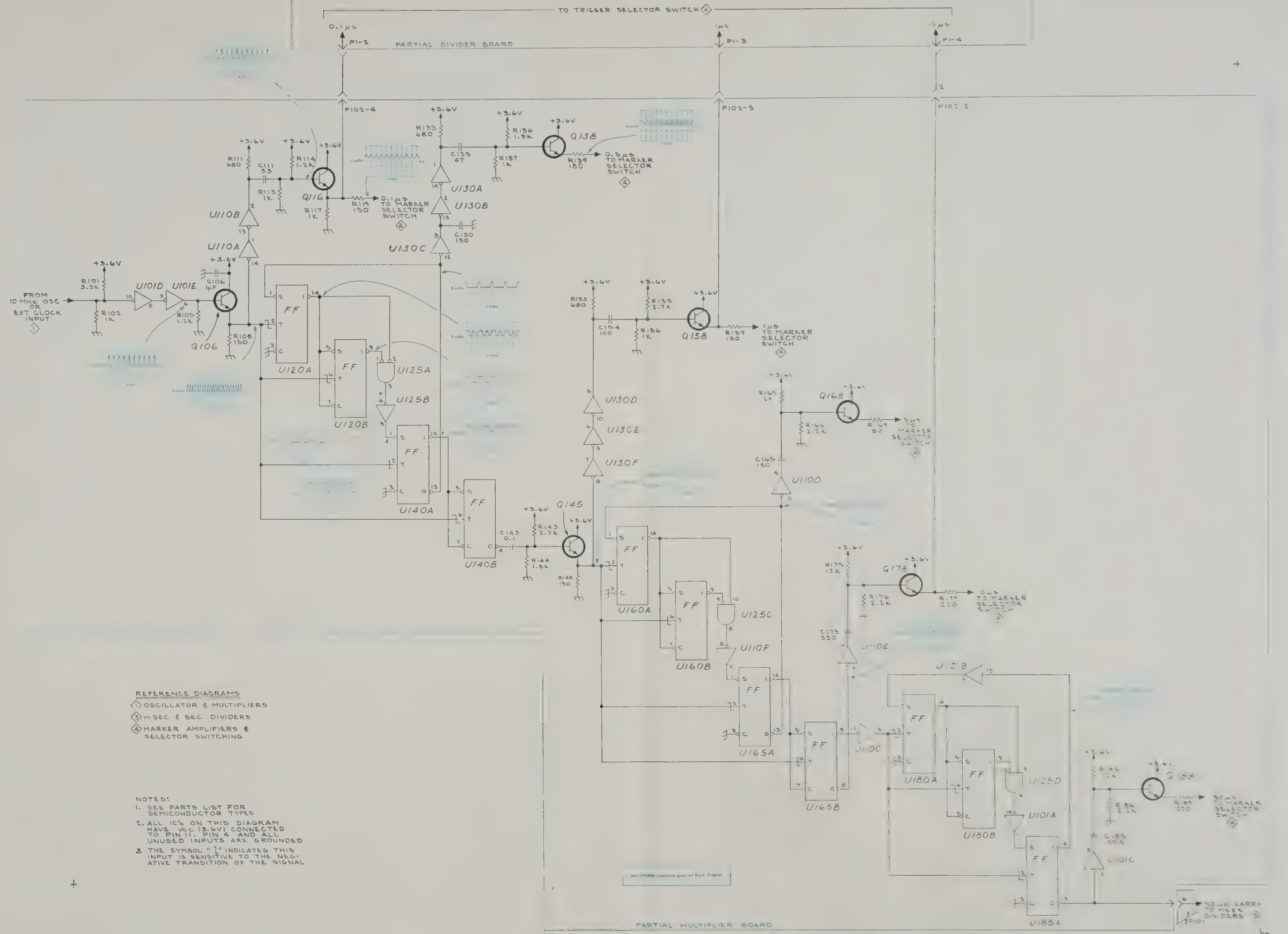
BLOCK DIAGRAM



REFERENCE DIAGRAMS
2 μ SEC DIVIDERS
4 MARKER AMPLIFIER & SELECTOR SWITCHING

NOTE:
1. SEE PARTS LIST FOR SEMICONDUCTOR TYPES

OSCILLATOR & MULTIPLIERS 1



REFERENCE DIAGRAMS

(1) OSCILLATOR & MULTIPLIERS

(3) mSEC & SEC DIVIDERS

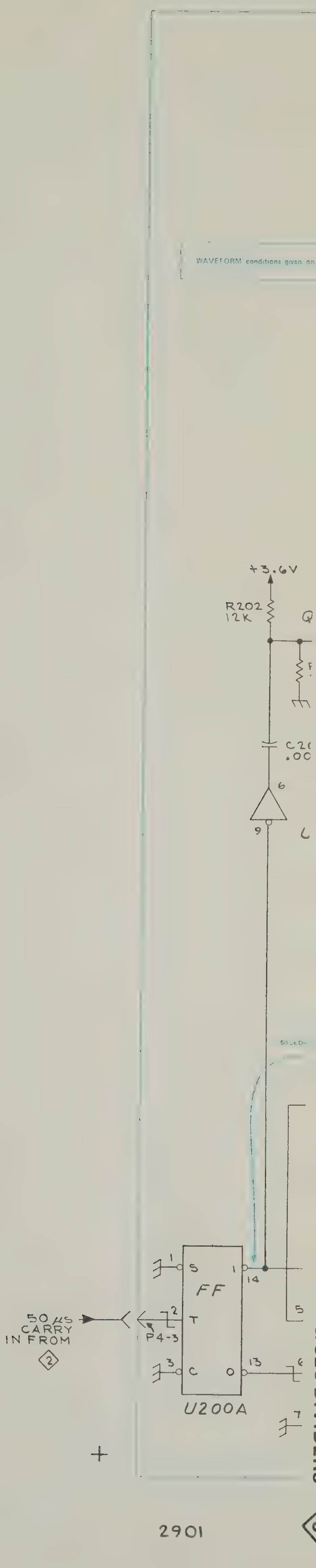
(4) MARKER AMPLIFIERS & SELECTOR SWITCHING

NOTES:

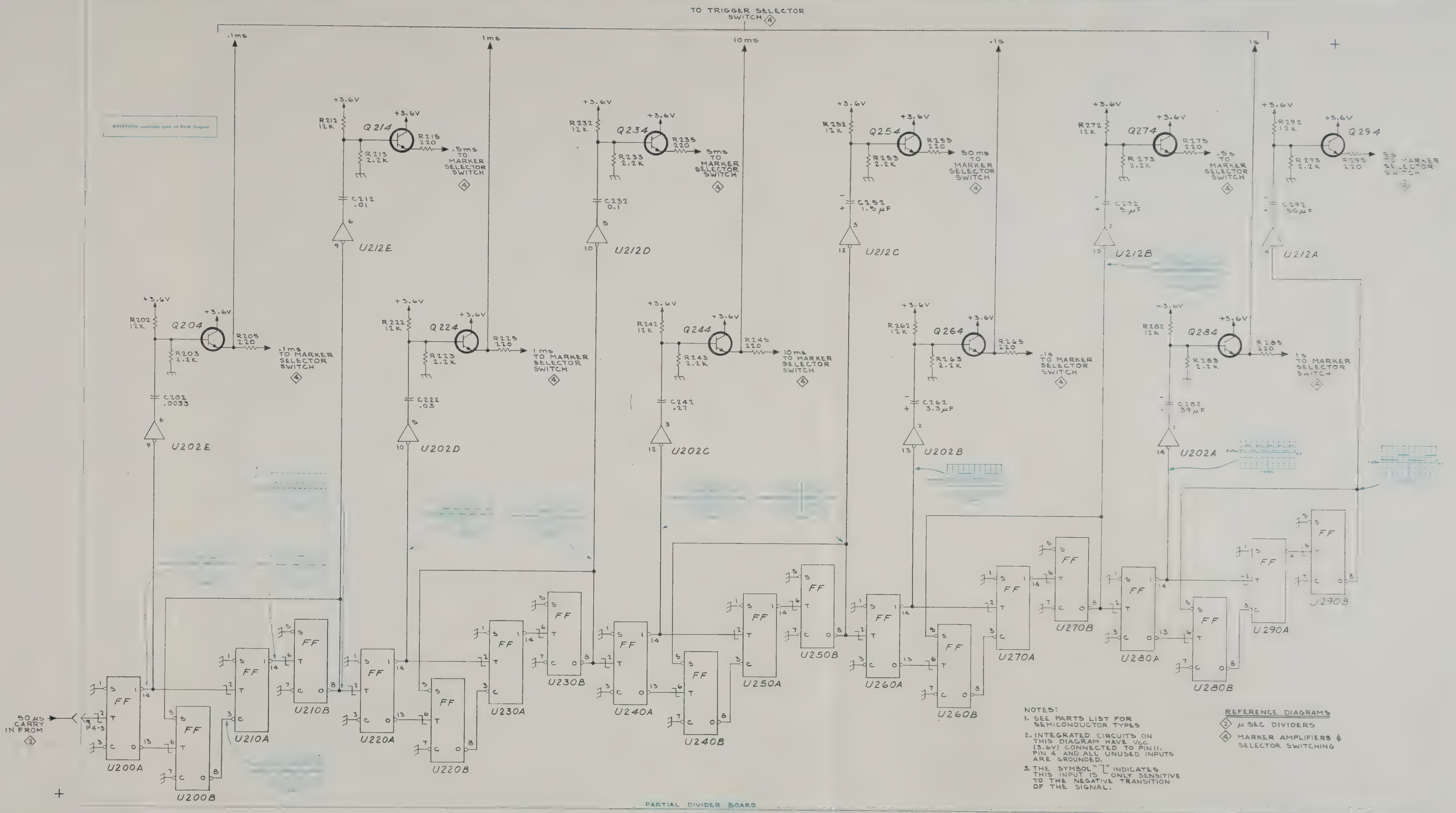
1. SEE PARTS LIST FOR SEMICONDUCTOR TYPES
2. ALL IC's ON THIS DIAGRAM HAVE Vcc (3.6V) CONNECTED TO PIN 11. PIN 4 AND ALL UNUSED INPUTS ARE GROUNDED
3. THE SYMBOL "]" INDICATES THIS INPUT IS SENSITIVE TO THE NEGATIVE TRANSITION OF THE SIGNAL

2901

μ SEC DIVIDERS (2)



WAVEFORM conditions given on
+3.6V
R202
12K
Q
C2(
.OC
FF
S
T
C
U200A
50 µs
CARRY
IN FROM
2
P4-3



NOTES:
1. SEE PARTS LIST FOR SEMICONDUCTOR TYPES
2. INTEGRATED CIRCUITS ON THIS DIAGRAM HAVE Vcc (3.6V) CONNECTED TO PIN 11. PIN 4 AND ALL UNUSED INPUTS ARE GROUNDED.
3. THE SYMBOL "⌐" INDICATES THIS INPUT IS ONLY SENSITIVE TO THE NEGATIVE TRANSITION OF THE SIGNAL.

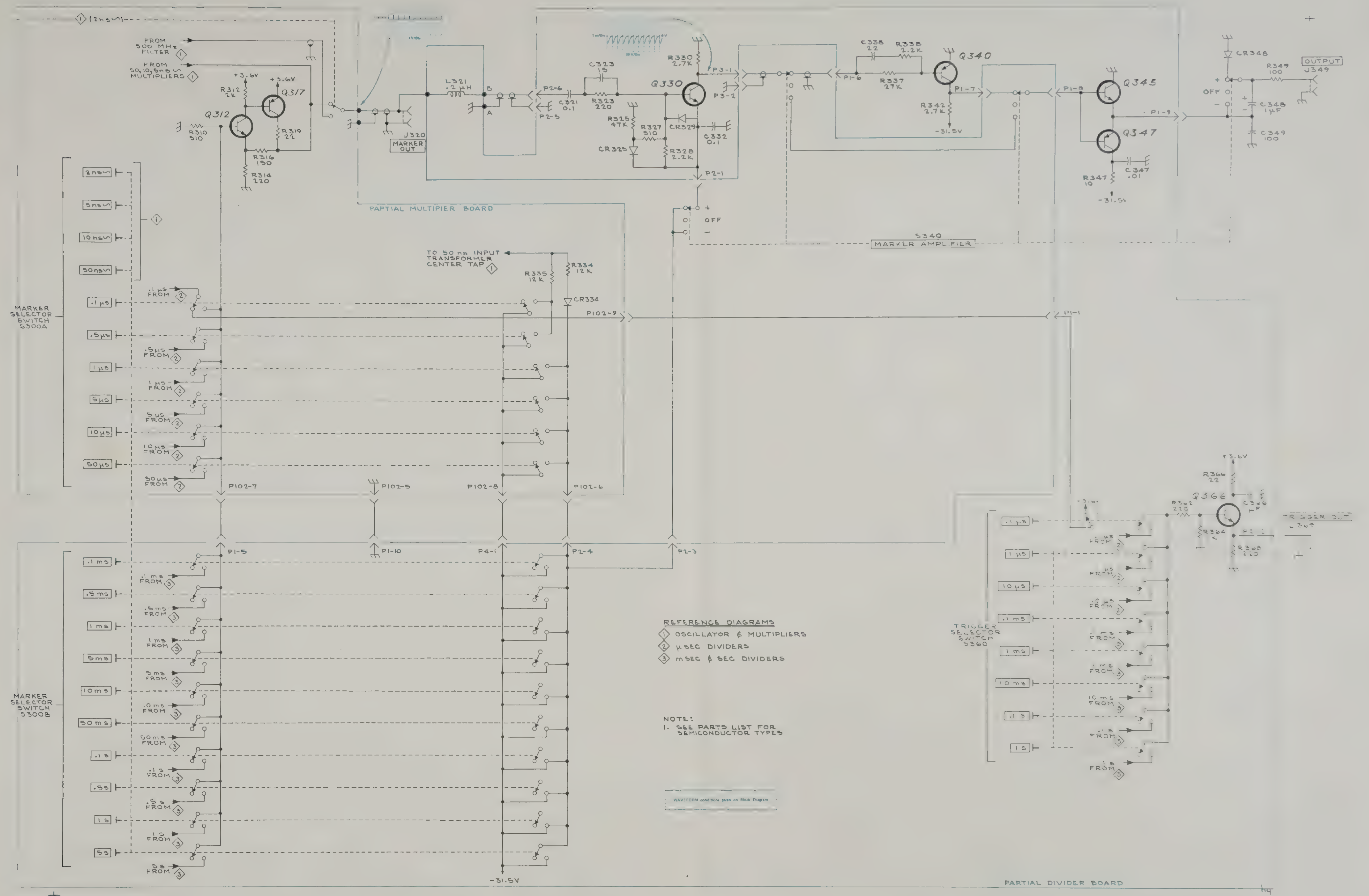
REFERENCE DIAGRAMS
2 μSEC DIVIDERS
4 MARKER AMPLIFIERS & SELECTOR SWITCHING

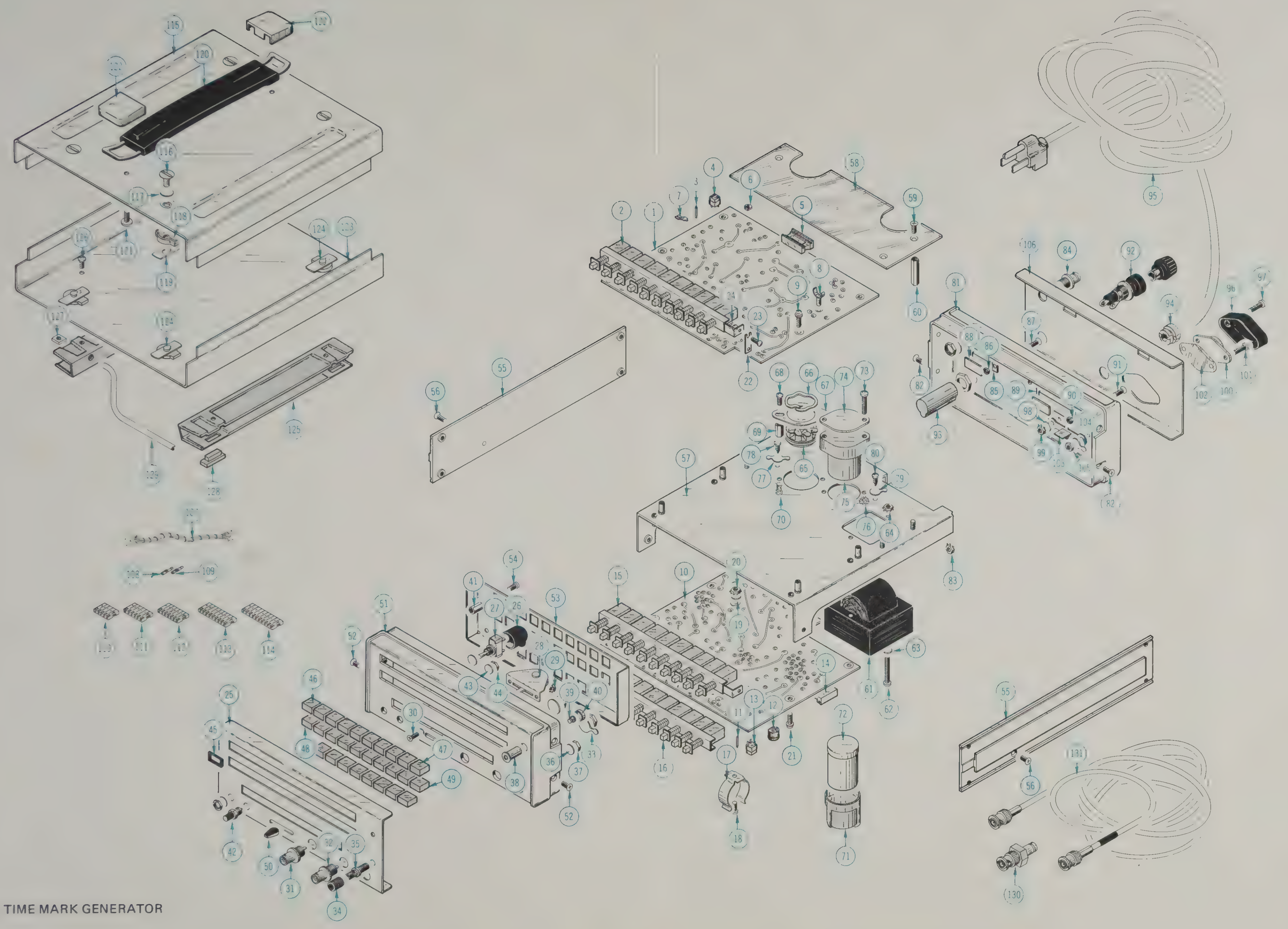
2901

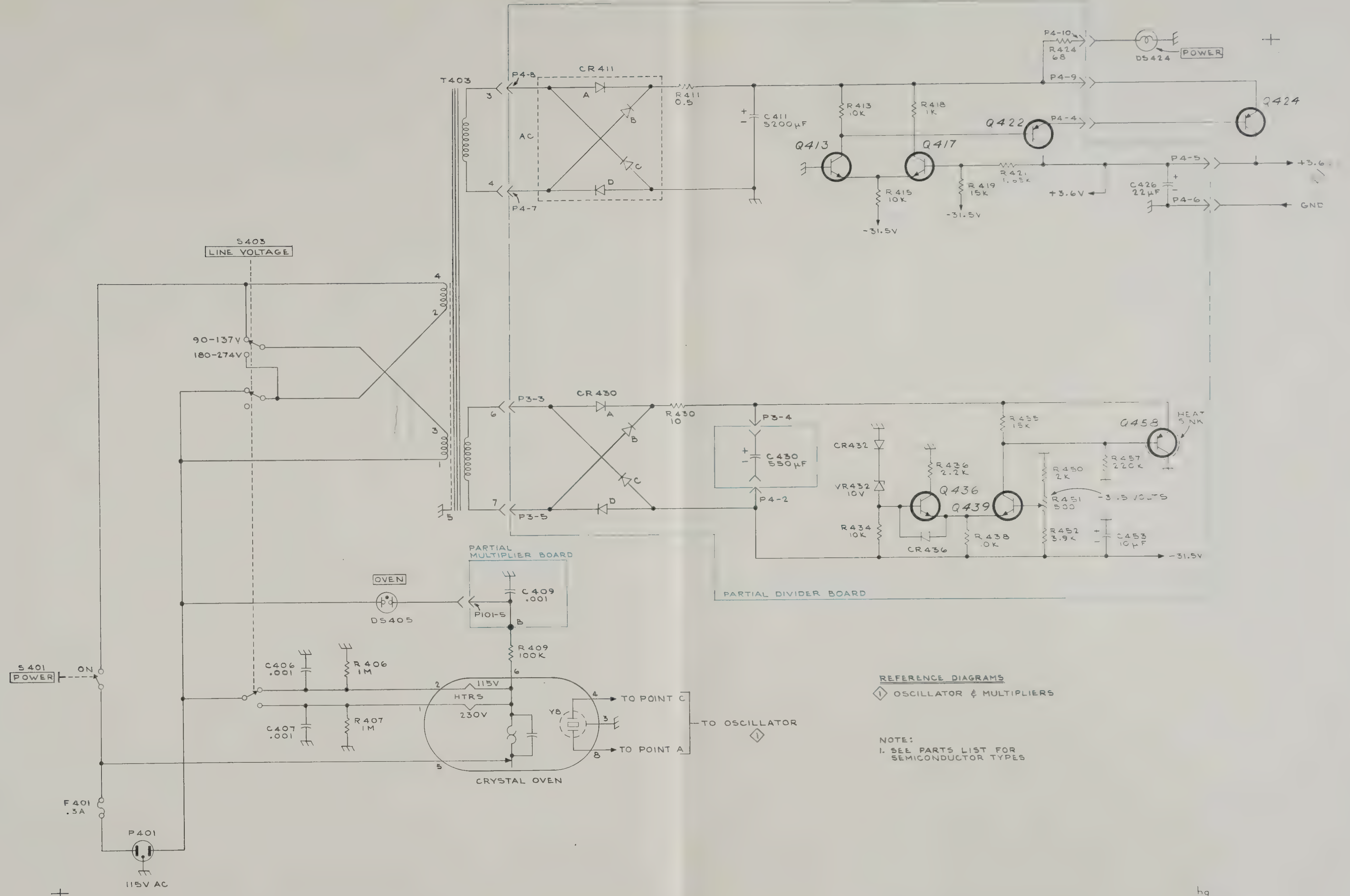
A

hq
0370

mSEC & SEC DIVIDERS 3

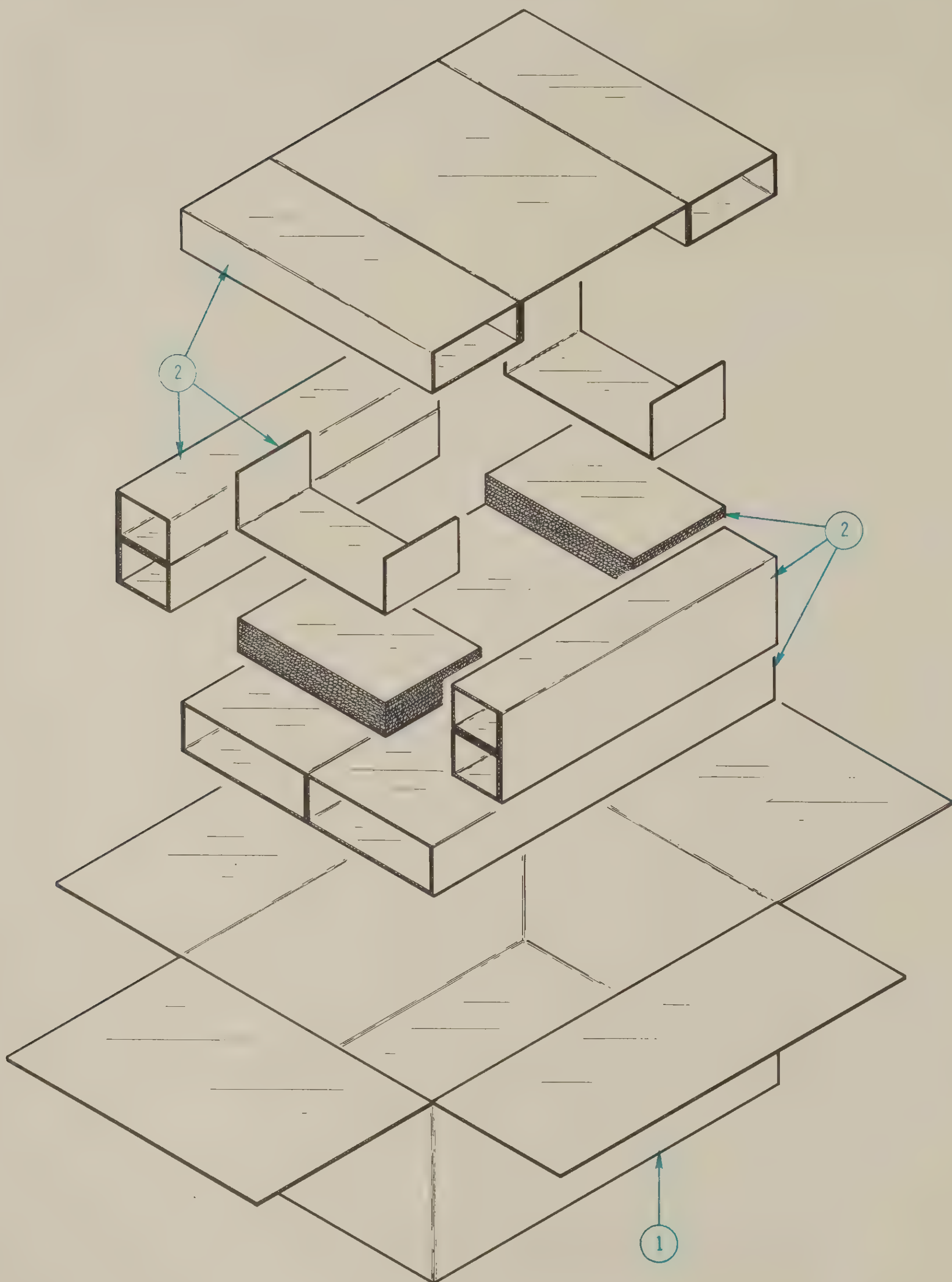

PARTIAL MULTIPLIER BOARD
MARKER SELECTOR SWITCH S300A
MARKER SELECTOR SWITCH S300B
S340 MARKER AMPLIFIER
TRIGGER SELECTOR SWITCH S360
PARTIAL DIVIDER BOARD
OUTPUT J349
MARKER OUT
REFERENCE DIAGRAMS
1 OSCILLATOR & MULTIPLIERS
2 μSEC DIVIDERS
3 mSEC & SEC DIVIDERS
NOTE:
1. SEE PARTS LIST FOR SEMICONDUCTOR TYPES





POWER SUPPLY ⑤

CARTON ASSEMBLY
(Part No. 065-0134-00)



Ⓐ

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
2-	065-0134-00			1	CARTON ASSEMBLY
	- - - - - -			-	assembly includes:
-1	004-0682-00			1	CARTON
-2	004-1072-00			1	PAD SET

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear either on the back of the diagrams or on pullout pages immediately following the diagrams of the instruction manual.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the Description column.

Assembly and/or Component
  Detail Part of Assembly and/or Component
  mounting hardware for Detail Part
    Parts of Detail Part
    mounting hardware for Parts of Detail Part
mounting hardware for Assembly and/or Component

Mounting hardware always appears in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

Mounting hardware must be purchased separately, unless otherwise specified.

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

ABBREVIATIONS AND SYMBOLS

For an explanation of the abbreviations and symbols used in this section, please refer to the page immediately preceding the Electrical Parts List in this instruction manual.

INDEX OF MECHANICAL & REPACKAGING PARTS ILLUSTRATIONS

SECTION 8
MECHANICAL PARTS LIST

FIGURE 1 EXPLODED

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-1	670-0315-00			1	CIRCUIT BOARD ASSEMBLY—MULTIPLIER
	- - - - - -			-	circuit board assembly includes:
	388-1415-00			1	BOARD, circuit
-2	260-1111-00			1	SWITCH, push—MARKER SELECTOR, upper
-3	131-0589-00			16	TERMINAL, pin, 0.50 inch long
-4	136-0220-00			19	SOCKET, transistor, 3 pin, square
-5	136-0269-00			10	SOCKET, integrated circuit, 14 contact
-6	136-0350-00			1	SOCKET, transistor, 3 pin, low profile
-7	344-0205-00			1	CLIP, electrical
-8	426-0121-00			2	MOUNT, toroid, plastic
	- - - - - -			-	mounting hardware: (not included w/circuit board assembly)
-9	211-0116-00			4	SCREW, sems, 4-40 x 0.312 inch, PHB
-10	670-0314-00			1	CIRCUIT BOARD ASSEMBLY—DIVIDER
	- - - - - -			-	circuit board assembly includes:
	388-1414-00			1	BOARD, circuit
-11	131-0589-00			31	TERMINAL, pin, 0.50 inch long
-12	136-0183-00			1	SOCKET, transistor, 3 pin
-13	136-0220-00			20	SOCKET, transistor, 3 pin, square
-14	136-0269-00			12	SOCKET, integrated circuit, 14 contact
-15	260-1110-00			1	SWITCH, push—MARKER-SELECTOR, lower
-16	260-1109-00			1	SWITCH, push—TRIGGER-SELECTOR
-17	344-0118-00			1	CLIP, capacitor mounting
	- - - - - -			-	mounting hardware: (not included w/clip)
-18	211-0504-00			1	SCREW, 6-32 x 0.25 inch, PHS
-19	210-0907-00			1	WASHER, flat, 0.25 inch diameter
-20	210-0407-00			1	NUT, hex., 6-32 x 0.25 inch
	- - - - - -			-	mounting hardware: (not included w/circuit board assembly)
-21	211-0116-00			4	SCREW, sems, 4-40 x 0.312 inch, PHB
-22	105-0159-00			1	LATCH, bar, switch
	- - - - - -			-	mounting hardware: (not included w/latch)
-23	211-0079-00			2	SCREW, 2-56 x 0.188 inch, PHS
	210-0001-00			2	WASHER, lock, internal, #2
-24	210-0405-00			2	NUT, hex., 2-56 x 0.188 inch
-25	333-1306-00			1	PANEL, front
-26	200-0799-00			1	COVER, plastic, 0.505 ID x 0.772 inch OD
-27	260-0613-00			1	SWITCH, toggle—POWER, w/hardware
-28	260-0726-00			1	SWITCH, lever—MARKER AMPLIFIER
	- - - - - -			-	mounting hardware: (not included w/switch)
-29	210-0586-00			2	NUT, keps, 4-40 x 0.25 inch
-30	211-0038-00			2	SCREW, 4-40 x 0.312 inch, 100° csk, FHS

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-31	131-0955-00			1	CONNECTOR, receptacle, BNC, w/hardware
-32	131-0955-00			2	CONNECTOR, receptacle, BNC, w/hardware
	- - - - - -			-	mounting hardware for each: (not included w/connector)
-33	210-0255-00			1	LUG, solder, 0.375 inch
-34	200-0103-00			1	CAP, binding post
-35	355-0507-00			1	STEM, binding post
	- - - - - -			-	mounting hardware: (not included w/stem)
-36	210-0011-00			1	WASHER, lock, internal, 0.25 ID x 0.468 inch OD
-37	210-0455-00			1	NUT, hex., 0.25-28 x 0.375 inch
-38	352-0084-00			1	HOLDER, neon, plastic
-39	378-0541-00			1	FILTER, lens, neon
-40	200-0609-00			1	COVER, neon holder
-41	129-0257-00			4	POST, hex., metallic, 0.425 inch long
-42	136-0223-00			1	SOCKET, light
	- - - - - -			-	mounting hardware: (not included w/socket)
-43	210-0046-00			1	WASHER, lock, internal, 0.261 ID x 0.40 inch OD
-44	210-0562-00			1	NUT, hex., 0.25-40 x 0.312 inch
-45	426-0568-01			28	FRAME, pushbutton, plastic
-46	366-1162-05			1	PUSHBUTTON—2ns
	366-1162-04			1	PUSHBUTTON—5ns
	366-1162-06			1	PUSHBUTTON—10ns
	366-1162-07			1	PUSHBUTTON—50ns
	366-1162-08			2	PUSHBUTTON—0.1 μs
	366-1162-09			1	PUSHBUTTON—0.5 μs
	366-1162-10			1	PUSHBUTTON —1 μs
	366-1162-11			1	PUSHBUTTON—5 μs
	366-1162-12			2	PUSHBUTTON—10 μs
-47	366-1162-13			1	PUSHBUTTON—50 μs
-48	366-1162-14			2	PUSHBUTTON—0.1 ms
	366-1162-15			1	PUSHBUTTON—0.5 ms
	366-1162-16			2	PUSHBUTTON—1 ms
	366-1162-17			1	PUSHBUTTON—5 ms
	366-1162-18			2	PUSHBUTTON—10 ms
	366-1162-19			1	PUSHBUTTON—50 ms
	366-1162-20			2	PUSHBUTTON—0.1 s
	366-1162-21			1	PUSHBUTTON—0.5 s
	366-1162-22			2	PUSHBUTTON—1 s
-49	366-1162-23			1	PUSHBUTTON—5 s
-50	366-0215-02			1	KNOB, lever—MARKER AMPLIFIER
-51	386-1653-00			1	SUBPANEL, front
	- - - - - -			-	mounting hardware: (not included w/subpanel)
-52	211-0541-00			4	SCREW, 6-32 x 0.25 inch, 100° csk, FHS

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-53	337-1211-00			1	SHIELD, electrical
	- - - - - -			-	mounting hardware: (not included w/shield)
-54	211-0008-00			4	SCREW, 4-40 x 0.25 inch, PHS
-55	426-0633-00			2	FRAME SECTION, cabinet, right & left
	- - - - - -			-	mounting hardware for each: (not included w/frame section)
-56	211-0101-00			1	SCREW, 4-40 x 0.25 inch, 100° csk, FHS
-57	441-0903-00			1	CHASSIS
-58	337-1244-00			1	SHIELD, electrical, high voltage
	- - - - - -			-	mounting hardware: (not included w/shield)
-59	211-0101-00			4	SCREW, 4-40 x 0.25 inch, 100° csk, FHS
-60	129-0198-00			4	POST, hex., 0.188 x 0.74 inch long
-61	- - - - - -			1	TRANSFORMER
	- - - - - -			-	mounting hardware: (not included w/transformer)
-62	211-0027-00			2	SCREW, 4-40 x 1.50 inches, RHS
-63	210-0823-00			2	WASHER, fiber, 0.125 ID x 0.25 inch OD
-64	210-0586-00			2	NUT, keps, 4-40 x 0.25 inch
-65	136-0012-00			1	SOCKET, crystal
-72	- - - - - -			-	mounting hardware: (not included w/socket)
-66	354-0002-00			1	RING, socket retaining
-67	386-0251-00			1	PLATE
-68	211-0503-00			2	SCREW, 6-32 x 0.188 inch, PHS
-69	385-0127-00			2	ROD, hex., 0.25 x 0.281 inch
	- - - - - -			-	mounting hardware for each: (not included w/rod)
-70	211-0503-00			1	SCREW, 6-32 x 0.188 inch, PHS
-71	200-0533-00			1	COVER, capacitor
-72	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor)
-73	211-0516-00			2	SCREW, 6-32 x 0.875 inch, PHS
-74	386-0252-00			1	PLATE, capacitor, small
-75	432-0047-00			1	BASE, capacitor, small
-76	210-0457-00			2	NUT, keps, 6-32 x 0.312 inch
-77	210-0204-00			1	LUG, solder, DE #6
	- - - - - -			-	mounting hardware: (not included w/lug)
-78	213-0044-00			1	SCREW, thread forming, 5-32 x 0.188 inch, PHS

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-79	210-0202-00			1	LUG, solder, SE #6
	- - - - - -			-	mounting hardware: (not included w/lug)
-80	213-0044-00			1	SCREW, thread forming, 5-32 x 0.188 inch, PHS
-81	386-1654-00			1	SUBPANEL, rear
	- - - - - -			-	mounting hardware: (not included w/subpanel)
-82	211-0541-00			4	SCREW, 6-32 x 0.25 inch, 100° csk, FHS
-83	210-0457-00			4	NUT, keps, 6-32 x 0.312 inch
-84	131-0342-00			1	CONNECTOR, BNC, female, w/hardware
-85	260-0447-00			1	SWITCH, slide—CLOCK
	- - - - - -			-	mounting hardware: (not included w/switch)
-86	210-0406-00			2	NUT, hex., 4-40 x 0.188 inch
-87	211-0101-00			2	SCREW, 4-40 x 0.25 inch, 100° csk, FHS
-88	337-1036-00			3	SHIELD, solder, fiber, slide switch
-89	260-0747-00			1	SWITCH, slide, double, line voltage
	- - - - - -			-	mounting hardware: (not included w/switch)
-90	210-0406-00			2	NUT, hex., 4-40 x 0.188 inch
-91	211-0101-00			2	SCREW, 4-40 x 0.25 inch, 100° csk, FHS
-92	352-0076-00			1	HOLDER, fuse, w/hardware
	- - - - - -			-	mounting hardware: (not included w/holder)
	210-0873-00			1	WASHER, rubber, 0.50 ID x 0.687 inch OD
-93	200-0237-00			1	COVER, fuse holder
-94	358-0161-00			1	BUSHING, strain relief
-95	161-0049-00			1	CABLE ASSEMBLY, power
-96	200-0692-00			1	COVER, transistor
	- - - - - -			-	mounting hardware: (not included w/cover)
-97	211-0513-00			1	SCREW, 6-32 x 0.625 inch, PHS
-98	210-0802-00			1	WASHER, flat, 0.15 ID x 0.312 inch OD
-99	210-0457-00			1	NUT, keps, 6-32 x 0.312 inch
-100	- - - - - -			1	TRANSISTOR
	- - - - - -			-	mounting hardware: (not included w/transistor)
-101	211-0578-00			1	SCREW, 6-32 x 0.437 inch, PHS
-102	386-0978-00			1	PLATE, insulator, mica
-103	352-0026-00			1	INSULATOR, transistor
-104	210-0202-00			1	LUG, solder, SE #6
-105	210-0457-00			1	NUT, keps, 6-32 x 0.312 inch

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-106	333-1307-00			1	PANEL, rear
-107	179-1450-00			1	WIRING HARNESS, chassis
	- - - - - -			-	wiring harness includes:
-108	131-0621-00			44	CONNECTOR, terminal
-109	131-0622-00			3	CONNECTOR, terminal
-110	352-0201-00			1	HOLDER, terminal connector, 5 wire
-111	352-0202-00			1	HOLDER, terminal connector, 6 wire
-112	352-0203-00			1	HOLDER, terminal connector, 7 wire
-113	352-0205-00			1	HOLDER, terminal connector, 9 wire
-114	352-0206-00			2	HOLDER, terminal connector, 10 wire
	179-1451-00			1	WIRING HARNESS, AC
-115	390-0148-00			1	CABINET TOP
	- - - - - -			-	cabinet top includes:
	214-0812-00			4	LATCH ASSEMBLY
	- - - - - -			-	each latch assembly includes:
-116	214-0603-01			1	PIN, securing
-117	214-0604-00			1	SPRING, latch
-118	386-0227-00			1	PLATE, index
-119	386-0226-00			1	PLATE, locking
-120	367-0037-00			1	HANDLE, carrying
	- - - - - -			-	mounting hardware: (not included w/handle)
-121	213-0155-00			2	SCREW, 10-32 x 0.40 inch
-122	344-0098-00			2	CLIP
-123	390-0149-00			1	CABINET BOTTOM
	- - - - - -			-	cabinet bottom includes:
-124	214-0812-00			4	LATCH ASSEMBLY
	- - - - - -			-	each assembly includes:
	214-0603-01			1	PIN, securing
	214-0604-00			1	SPRING, latch
	386-0227-00			1	PLATE, index
	386-0226-00			1	PLATE locking
-125	348-0256-00			2	FOOT, cabinet
	- - - - - -			-	mounting hardware for each: (not included w/foot)
-126	211-0507-00			2	SCREW, 6-32 x 0.312 inch, PHS
-127	220-0419-00			2	NUT, square, 6-32 x 0.312 inch
-128	348-0254-00			4	PAD, cabinet foot
-129	348-0257-00			1	FLIP-STAND, cabinet

STANDARD ACCESSORIES

Fig. & Index No.	Tektronix Part No.	Eff	Disc	Qty	Description
-130	011-0049-01			1	TERMINATION, coaxial, 50 ohm
-131	012-0057-01			2	CABLE ASSEMBLY, 50 ohm, coaxial
	070-0995-00			2	MANUAL, instruction (not shown)

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.

TEXT CORRECTION

Section 1 Specification

Page 1-2 Electrical Characteristics

CHANGE: a portion of the table to read:

MARKER AMPLIFIER OUTPUT	Amplified 5 s to 1 μs positive or negative-going time markers. Amplitude (5 s to 5 μs markers) at least 25 V into 1 kΩ load. Amplitude 1 μs marker at least 22 V into 1 kΩ load.

Input Power Requirements

CHANGE: the two voltage ranges under Line Voltage to read:

Line Voltage	
115 V Range	90 V to 136 V.
230 V Range	180 V to 272 V.

Section 5 Performance Check/Calibration

Page 5-12 10. Check Marker Amplifier Output

CHANGE: part b to read:

b. Requirement--Positive and negative-going markers with amplitude that equals or exceeds 25 V peak into 1 kΩ load except 1 μs marker which should equal or exceed 22 V peak into 1 kΩ load.

Sections 6 & 7

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTIONS

DIVIDER Circuit Board Assembly

CHANGE TO:

C348	290-0177-00	1.0 μF	50 V	EMT	
L321	108-0368-00	10 μH			
Q345	151-0179-00	Silicon		2N3877A	
R342	316-0152-00	1.5 kΩ	1/4 W		10%
R347	315-0330-00	33 Ω	1/4 W		5%

MULTIPLIER Circuit Board Assembly

ADD:

C106	283-0177-00	1 μF	Cer	25 V	+80%-20%

Power Supply ⟨5⟩

CHANGE: all reference to 31.5 volt supply to 30 volts.

CHANGE: secondary winding of T403 for 3.6 V supply should be terminals 8 and 9.